47.3 38.0 1.4 23.1
29.1 29.0

FINAL REPORT

RESEARCH AND SURVEYS

FEDERAL AID PROJECT NO. F-41-R

FACTORS INFLUENCING FISH POPULATIONS IN OKLAHOMA LAKES AND PONDS

JOB NO. 9

COMPARATIVE BIOLOGY AND ECOLOGY CRAPPIE IN COPAN LAKE

JULY 1, 1982 THRU JUNE 30, 1986

FINAL REPORT

State: OKLAHOMA Project No.: F-41-R

Project Title: Factors Influencing Fish Populations in Oklahoma Lakes and Ponds

Project Section: Research and Surveys

Job Number: IX

Job Title: Comparative Biology and Ecology of Crappie in Copan Lake

Contract Period: 1 July 1982 through 30 June 1986

Program Narrative Objective Number: IX

Objective: To relate crappie relative abundance, growth rates, size frequency, age structure, condition, and food habits to invertebrate densities and physical factors in Copan Lake.

I. JOB OBJECTIVES

A. Determine the relationship of selected physical and biological factors to population parameters of crappie.

B. Examine resource partitioning among crappie and relate these findings to the relative success and growth rates of the species in Copan Reservoir.

II. ABSTRACT

The distribution of common fish species relative to resource availability was evaluated seasonally from winter 1983-1984 to fall 1985. Water quality characteristics of Copan Reservoir were evaluated seasonally to estimate potential effects on fish distributions. Habitat preference of common species was evaluated using frequency of occurrence data and an index of habitat availability derived from the measurement of water depths and bottom-type at each sampling location. Significant changes in relative abundances were attributed to periodic increases in reservoir discharge.

Water quality characteristics were generally homogenous among sampling locations within seasons. Variables with small among-site variances were

assumed to have no influence on fish distributions. Fluctuating turbidity levels did not decrease catch of common species or suppress plankton biomass. Localized reductions in dissolved oxygen limited habitat use in Endacott's Pond and in areas of heterotrophic degradation of organic matter.

Seven species accounted for about 79% of the total catch. White crappie was the most abundant species in the reservoir, representing about 16% of all fishes collected. Other abundant species included white bass, spotted gar, gizzard shad, crap, black bullhead, and bluegill. Biomass of white bass and spotted gar decreased markedly during 1984. White crappie maintained significant biomass levels throughout the study. Biomass and relative abundance data suggest the distributions of black bullhead and carp were ubiquitous within the reservoir. The biomass of gizzard shad increased during the study, but showed wide seasonal fluctuations.

White crappie preferred shallow water during all seasons except summer, when individuals were taken predominantly from depths exceeding 2 m. The population was commonly associated with broken and interrupted habitats or heterogeneous habitats, preferring the latter during spring. The greatest percentage of spawning individuals during this time was taken in broken, interrupted habitats characteristic of shoreline expenses.

White bass and gizzard shad distributions were similar only during winter, when the populations were collected in shallow areas of low complexity. At other seasons, the distributions of these species were incongruent. Gizzard shad remained in surface waters of low complexity habitats throughout spring and summer, then moved to greater depths during fall. In contrast, white bass preferred greater depths during summer and shallow shoreline expanses during fall.

Carp and black bullhead distributions were often associated with complex habitats. During spring, these species moved into newly inundated areas of flooded vegetation.

White crappie were more abundant and widespread in Copan Lake than black crappie. Black crappie were generally restricted to Endacott's Pond, an adjacent subimpoundment inundated by the reservoir. Stunting was not evident in either crappie population during the first year (1983) of impoundment or in subsequent years of the study. Both crappie species collected in the main reservoir had faster growth rates, higher relative weights, and appeared to have earlier age related mortality than crappie collected in Endacott's Pond. Relative weights of crappie declined during summer; however, relative weights generally increased with age.

Thirty-eight enzymes were examined with standard methods of horizontal starch gel electrophoresis. Little genetic variation was found in either population. White crappie were polymorphic at IDH-2 and CK-3. Black crappie had variation at these loci, but were fixed below 0.05 levels. Hybrid black crappie X white crappie comprised 6% of phenotypic black crappie.

Our data indicated that crappie captured with piscivorous components in their stomachs ("piscivores") had faster growth rates and higher relative weights than equivalent size fish with insectivorous components in their stomachs ("insectivores"). Crappie with insect and fish in their stomachs ("omnivores") had higher summer relative weight and appeared to have greater longevity than "piscivorous" or "insectivorous" crappies.

III. BACKGROUND

Black and white crappie (Pomoxis nigromaculatus and P. annularis, respectively) are widely distributed throughout North America. Field observations indicate that when both species occur sympatrically, black crappie usually predominate in clear, cooler, slightly acidic water, whereas white crappie predominate in water that is warmer, more turbid, and slightly basic (Hall et al. 1954; Goodson 1966).

Crappie populations often increase dramatically in newly created midwestern reservoirs. Growth rates of sympatric black and white crappie are generally high the first few years after impoundment, but subsequently decline (Rutledge and Barron 1972). Abundance of black crappie also tends to decline, and although white crappie remain relatively abundant, the population is often composed of many "stunted" or small fish (Jenkins 1953; Glass 1982). In general, midwestern reservoir crappie populations tend to be characterized by dominant, small, or missing year classes (Cichra et al. 1981; Mitzner 1981; Beam 1983).

Several hypotheses have been presented to explain the decline of black crappie populations in aging midwestern reservoirs. Generally, researchers speculate that the decreased growth rates of black crappie in aging reservoirs and the selective advantage white crappie have in older midwestern reservoirs is related to interspecific competition for limited forage (Stevens 1958; Keast 1968; Li et. al. 1976) and severe intraspecific competition due to overcrowding (Huish 1953; Rutledge and Barron 1972; Hanson et al. 1983; Gablehouse 1984).

The differences of growth and survival of black and white crappie populations may be related to their feeding biology. Crappie feed

primarily on zooplankton as fry, and begin feeding on aquatic insects at 120 mm, and switch to fish at 150 mm (Heidinger et al. 1985). White crappie are considered more piscivorous than black crappie and often switch to piscivory at a smaller size. Ball and Kilambi (1972) found that foraging differences may have accounted for a decline of black crappie and an increase of white crappie in subsequent years following impoundment of Beaver Reservoir. During the early period of impoundment, both species of crappie ate earthworms in winter and spring, and fed on gizzard shad (Dorosoma cepedianum) during the remainder of the seasons. White crappie apparently concentrated on shad even when earthworms were available. However, in the later impoundment period, black crappie ate benthic insects during spring, and fish in other seasons, whereas, white crappie ate shad year round.

Foraging behavior of black and white crappie may be specific for each population. Black crappie have been reported to be opportunistic; small crappie feed on zooplankton and invertebrates but many larger crappie switch to piscivory (Keast 1968; May and Thompson 1974; Ager 1975). Although large black crappie may be piscivorous, they do not necessarily stop feeding on invertebrates. Ager (1975) found that larger black crappie (> 239 mm TL) consumed more fish than did smaller black crappie, but there was no drop in the frequency of crustaceans and insects in their diet. The introduction of forage fish, however, significantly changed the forage behavior of black crappie in Lake Powell (May and Thompson 1974). Before the introduction of forage fish, Lake Powell black crappie fed on zooplankton and insects when they were small and added fish to their diets when they grew larger. After

the introduction of threadfin shad (Dorosoma petenense), all size classes of black crappie fed on shad.

Increased growth rates and condition have been reported for black and white crappie that switched to piscivory in comparison to crappie that remained nonpiscivorous (Ellison 1984; Heidinger et al. 1985). In addition, Ellison (1984) reported age related mortality in older black crappie that failed to increase daily ration by switching to piscivory at the appropriate size (> 200 mm TL). Apparently, the forage of older, nonpiscivorous crappie was not sufficient to supply the annual energy requirements, which resulted in an "energy trap" during summer. Nevertheless, some balanced midwestern crappie populations can be maintained on a diet of zooplankton and insects (Gablehouse 1984).

Not all crappie switch to piscivory at the same size (if at all). Keast (1968) and Heidinger et al. (1985) found feeding habits highly variable between and within crappie populations. Keast (1968) reasoned that even large black crappie could consume planktonic crustacea, possibly throughout life, because of a "specialized screen" of gill rakers (25-29) on the first arch. Tucker (1972) attributed the ability of young black crappie to maintain good condition througout the growing season to gill raker count. However, crappie larger than 150 mm TL were less adapted to feeding on small zooplankton because large spaces developed between gill rakers that prevented the retention of small food organisms (Wright et al. 1983).

Clearly, the feeding biology of crappie is variable and may vary between individuals in a population. Such variation probably affects the growth rates of individuals and populations. Paloheimo and Dickie (1966) found relatively large variation in growth efficiencies among

individuals and within individuals at different times. The affects of diet changes on growth, condition, and survival of crappie are poorly understood.

Another contributing factor to the decline of quality crappie populations in midwestern reservoirs may be the erosion of genetic variability in populations as they persist in aging reservoirs. Genetic variation is critically important in allowing adaptation to temporal and spatial changes in environmental conditions (Antonovics 1971; Avise and Selander 1972; Utter et al. 1973; Powers and Place 1978). Management programs usually operate on the assumption that the genetic makeup of crappie populations is fairly homogeneous and constant through time. It is also assumed that populations are composed of fish that are genetically capable of fast growth and can reach a large size if forage is available. These assumptions may not be valid when reservoir stocks of crappie are derived from indigenous populations in an inundated river (Hall et al. 1954), where previous riverine selective pressures have determined the genetic structure of the founding population. New reservoirs present a myriad of new selective pressures that possibly alter gene frequencies in crappie populations after impoundment.

Population size is the single most important factor in sustaining high levels of genetic variation within a population (Meffe 1986). All populations become increasingly inbred with time, but inbreeding occurs much sooner in smaller populations and could be important in black crappie populations in aging midwestern reservoirs. Inbreeding depression, resulting in increased homozygosity, tends to lower individual fitness as measured by growth rates, developmental stability,

survivorship, and fecundity (Meffe 1986). The ideal population is infinitely large. However, the effective breeding population is usually a subset of the total population, and is a function of the total number of breeding individuals, sex ratio, mating system, and variation in fecundity. Maintaining effective population size is important in resource management because it influences the genetic stability of populations, in that inbreeding and changes in gene frequency through sampling error (genetic drift) are inversely related to effective population size (Tave 1984).

Recent developments in techniques (primarily electrophoresis) have allowed natural resource managers to determine levels of genetic variation in natural populations (Smith et al. 1976). No previous study has examined the genetic structure of founding populations of black and white crappie in a new midwestern reservoir. Information on the genetic structure of founding populations is essential before the genetic structure of crappie populations in aging reservoirs can be evaluated.

Another contributing factor in the decrease in abundance of black crappie when they are in sympatry with a much larger white crappie population is reduction of effective population size through gamete competition. Species integrity may be governed more by pre-reproductive isolating mechanisms than by post-reproductive mechanisms. The creation and stocking of reservoirs has often mixed otherwise isolated populations of black and white crappie and forced them to share spawning sites (Jenkins 1953). Thus, it is possible that they hybridize wherever they occur together.

Although there is little information on the frequency of natural hybridization, Burr (1974) reported a white crappie X flier (Centrarchus

macropterus) hybrid, and other studies have attempted artificial hybridization of Pomoxis spp. with other species of Centrarchidae (West and Hester 1966; Tyus 1973; Merriner 1971). Metcalf et al. (1972) demonstrated that artificially reared F_1, F_2, and back-crossed black crappie X white crappie interspecific hybrids were hardy and fertile. In addition, they found that F_1 hybrids were not morphologically intermediate between black or white crappie but instead were fairly typical of black crappie, making field identification difficult. The vigor and fertility of experimental hybrid crappie populations led Metcalf et al. (1972) to suggest that natural hybridization may occur more frequently than expected and may have management implications.

The distribution and diversity of crappie and other fishes are controlled by structural features of the habitat which include current velocity, substrate, and depth (Shelford 1914, Shelford and Eddy 1929, Sheldon 1968). The catch of fish in reservoirs has been related to topographic features, depth of water, and sediment characteristics (Summerfelt 1971). Relative abundances of largemouth bass and bluegill have been found to increase in tree areas of lakes, whereas crappie abundances increased in open areas (Davis and Hughes 1971). The numerical abundance and spatial distribution of all species must be taken into account before an understanding of community organization can be obtained (Hairston 1959).

Fish populations which initially invade a new impoundment must restructure themselves within a changed environment. An initial period of high productivity characteristic of most species preceeds the development of fish assemblages dominated by lower trophic levels (Carlander 1955, Jenkins 1958). These alterations in the assemblage of fishes may be manifested as species addition, species replacement, or by changing relative abundances

(Gorman and Karr 1978). The addition of a competitor which is more effective in a given habitat can change the profitability ranking for a species to the extent that preferred habitats are abandoned (Werner and Hall 1979). Species introductions have been shown to have profound effects on the trophic levels within a tropical lake community (Zaret and Paine 1973). Ecological overlap, or a greater similarity between syntopic species, can presumably be greater in unsaturated habitats where competition is reduced (Pianka 1983). A major problem with the study of a reservoir system is that removal of fish may reduce the population to the extent where normal relationships between species are disrupted (Keast 1978).

Problems associated with the measurement of abiotic factors and quantification of fish species distribution in streams are reduced due to the linear configuration of these systems (Sheldon 1968). No congruent methodologies exist for relating habitat availability and complexity to fish species distributions in reservoirs. Implementation of standard habitat assessment procedures to define species preference of available depths, velocities, substrates, and temperature have been conducted in streams (Bovee and Cochnauer 1977, Orth 1980, Orth et al. 1982). Adaptation of existing methodologies for deriving frequency distributions of reservoir fishes relative to available habitat has not been done.

Detailed studies relating the distribution of fish populations and reservoir discharge are lacking. Summer flushing has been related to the loss of fish numbers, especially when flushing time was less than seven days (Walburg 1977). This suggests that extrinsic environmental perturbations of short duration may significantly impact the relative abundances and distributions of fish populations within reservoirs.

IV. STUDY AREA

Copan Reservoir is located in northeastern Oklahoma, approximately 3 km west of Copan (S30, T28N, R13E) in Washington County. The damsite is located at river km 11.9 on the Little Caney River--the major stream feeding into the reservoir. At conservation pool elevation, 216 m above mean sea level, the reservoir has a surface area of approximately 1,962 hectares, with a shoreline of 48.3 km (Hauth et al. 1986). The mean depth at conservation pool is 2.7 m. Copan Reservoir is a multipurpose project for flood control, water supply, water quality control, recreation, and fish and wildlife (Oklahoma Water Resources Board 1984).

The drainage area of the basin is about 1,347 km^2, of which about 1,308 km^2 are above the damsite. The little Caney River is a 111-km long tributary of the Caney River in the Verdigris River watershed, and lies in southeastern Kansas and northeastern Oklahoma. The major physiographic region of the water shed is the Osage Plains, which include the Chautauqua Hills south of the Neosho River (Schoewe 1949). The Chautauqua Hills are developed chiefly in the thick sandstones of the Douglas group formed during the Pennsylvanian Period. As a result of erosion in the sandstone belt the surface has been dissected into a range of low hills characteristically covered by oak-hickory forest; these hills differ in appearance from both the Big Caney watershed on the west and the Verdigris River watershed on the east. The gradient of the Little Caney River (= Middle Caney River; Metcalf 1959) in Chautauqua County, Kansas is 2.05 m/km. The entire division of the Chautauqua Sandstone Hills is intersected by many deeply incised streams.

Much of the vegetation within the basin was left intact prior to final impoundment on 1 April 1983. Dense vegetation persists in the northern half

of Copan Reservoir. As a result, a significant proportion of the total surface area was rendered impassible and necessitated the construction of a boat lane to allow traffic from the main body of Copan to reach the northern-most extent of the reservoir. Travel is also aided by a series of "siltation lanes" which traverse the width of the reservoir and intersect both the boat lane and Little Caney Channel.

The consequence of the many deeply incised streams characteristic of the drainage area is that the reservoir is subject to rapid and dramatic changes in volume. The interim flood control elevation of 216 m above mean sea level was achieved on 23 April 1983, less than one month after final impoundment. From 1 April 1983 to 31 May 1985, the volume of the reservoir was exchanged about 9.5 times, or approximately once every 2.7 months. A maximum surface elevation of 221.2 m occurred on 7 March 1985, representing an increase of 134.4 hm^3 above conservation pool level. This excess volume was achieved in a 15-day interval following less than 12.7 cm of rainfall during the previous month.

V. METHODS

1. Water Quality

The water quality of Copan Reservoir was characterized by seasonal analysis of selected variables measured at 10 standard sampling locations (Figure 1). Measurements were taken during the period August 1984 to June 1985.

Verticle profiles (meter intervals) were used to evaluate dissolved oxygen (DO), temperature, salinity, and conductivity. Single measurements at each location included pH, secchi transparency, alkalinity, and turbidity. YSI meters were used to measure DO, temperature, salinity, and conductivity.

A single water sample taken at 1 m depth was used to evaluate turbidity, whereas alkalinity values were derived from titration.

Four of the standard locations were used to determine concentrations of suspended metals and availability of nutrients. A Van dorn alpha bottle was used to take samples at a depth of 1 m. Ammonia, total nitrogen, and orthophosphate samples were deposited on ice in the field for transport to the laboratory, where final evaluation was done (Hach Chemical Company 1975). Metal samples were preserved in concentrated nitric acid (0.2N) in the field and analyzed for Na, Ca, Mg, K, Fe, Zn, Cu, Cr, Ni, Cd, Pb, and Si using a Perkin-Elmer 5000 atomic absorption spectrophotometer. Data for Na, Ca, Mg, K, and Fe were combined to estimate water hardness (Standard Methods 1971) at each site for each sampling period. Hardness values were used in a series of equations (EPA 1985) to evaluate maximum allowable toxicity criteria (MATC) for the reservoir. The formulae were:

$$\text{Cu MATC} = e^{[0.8545 \ln (hd) - 1.465]}$$

$$\text{Pb MATC} = e^{[1.266 \ln (hd) - 4.661]}$$

$$\text{Zn MATC} = e^{[0.83 \ln (hd) + 1.95]}$$

$$\text{Ni MATC} = e^{[0.76 \ln (hd) + 4.02]}$$

$$\text{Cr MATC} = e^{[0.3190 \ln (hd) + 1.561]}$$

$$\text{Cd MATC} = e^{[0.785 \ln (hd) - 3.490]}$$

where hardness is 104.119 ppm. These equations were used specifically to evaluate four-day average metal concentrations. The MATC of unionized ammonia was also evaluated using a four-day average concentration reference table (EPA 1985).

2. Plankton

The reservoir plankton community was sampled during seasonal water quality assessment procedures and monthly fish collection procedures. A number 20 Wisconsin plankton net was used to sample 10 verticle meters of the water column at each location. Each concentrated sample (approximately 100 ml) was immediately preserved in 1% Lugol's solution (Pennak 1978).

Subsequent to enumeration of plankton, each sample was agitated to achieve a random suspension. A 1 ml subsample was then extracted for identification of plankton to the lowest taxonomic unit possible. All counts were multiplied by 100 to estimate density.

Biomass estimates were derived using the gravimetric method (Standard Methods 1971); however, ash-free dry weight was not obtained. Samples were filtered using a Millipore filter and pre-dried and weighed 50 um filter paper. Filtered samples were then dried for 12 h at 50 C and placed in desiccators until each cooled to room temperature. Samples were then weighed to the nearest thousandth gram, and actual weight calculated as the difference between filtered sample weight and filter paper weight. Biomass estimates were then derived using 113.1 l as the actual volume of reservoir represented by each sample.

3. Benthos

The reservoir benthic community was sampled monthly in conjunction with fish collection procedures. Initially, an Eckman dredge was used to retrieve bottom samples, but the inefficiency of this method led to the use of a Peterson dredge. Efforts to quantify biomass and density of benthic invertebrates was abandoned after repeated attempts to sample standard volumes

of substrate failed. Invertebrates were separated from the substrate in the field and identified to the lowest taxonomic unit possible.

4. Collection of Fishes

Fishes were collected using barrel nets, frame nets, experimental gill nets, and electroshocking. The barrel nets were 1.4 m in length and 0.9 m in diameter, with concave funnel ends terminating in apertures 0.2 m in diameter. These nets were most efficient when fished for relatively short periods of time in shallow water.

The frame nets were modified fyke nets with 1.27 cm mesh and an initial rectangular heart (two frames, each 1.83 m x 0.91 m) followed by a series of four hoops, 0.76 m in diameter. A single 20-m lead net was used to direct fish into the mouth of the net.

Frame nets were usually set in shallow water perpendicular to the shoreline in order to intercept fish movement occurring parallel to shoreline. Frame nets and barrel nets were used in combination to sample near-shore habitats.

Experimental gill nets were multifilament nylon and were 45.72 m in length and 2.44 m in depth. Each net was comprised of five 9.14 m panels with mesh sizes of 1.91, 2.54, 3.18, 3.81, and 5.08 cm (square mesh). All gill nets were anchored and fished on the bottom.

Occasionally, electroshocking was used to sample fishes from standard localities. Inclement weather, logistic constraints imposed by the distance to the reservoir, and equipment malfunction prevented the consistent use of electroshocking. The apparatus consisted of a 4.88 m heavy guage aluminum jon boat equipped with a Sears 3000 watt generator and Coffelt VVP-15 voltage regulator. Electrofishing was conducted for a period of 1-h at each site.

Nets were monitored every 14-h, including two 6-h intervals during the day, and one 12-h interval at night. Collected fishes were weighed to the nearest gram; total and standard lengths were measured to the nearest millimeter. Subsamples of 20 individuals were randomly selected from species represented by exceedingly large numbers in the catch. Biomass of these species was then estimated using the known quantities of the subsample and extrapolating to the actual sample.

5. Habitat

Complexity of sampled habitats was estimated from measurements of depths and substrates. Depths were measured to the nearest cm; bottom-types were numerically coded and classified in relation to increasing structural features (Table 1).

Measurements were taken using 1.27 cm diameter aluminum-alloy conduit incremented by centimeters. Four 3-m sections of conduit were attached sequentially as required for greater depths.

A grid of point measurements was used relative to each type of sampling gear to derive mean depth and substrate values for each sampled habitat. Grids associated with experimental gill nets yielded mean habitat values for an area of 625 m^2; frame net areas were 500 m^2, and barrel net areas were 225 m^2. Sampled habitats with similar mean depth and substrate values were combined within each season. Seasonal substrate complexity intervals were generalized: 0-1.9, even and uninterrupted; 2-3.9, coarse and occasionally interrupted; 4-5.9, broken and interrupted; 6-7.9, high standard deviation (heterogeneous); > 8, greatly dissected. The Chi-Square goodness of fit test (Conover 1971) was used to test the hypothesis that fish distributions were

Table 1. Classification of bottom types in relation to increasing structural features.

Code	Substrate	Approximate particle size (mm)
1	Silt	$\leq$ 0.45
2	Silt-sand	-
3	Sand	.600-4
4	Sand-gravel	-
5	Gravel	4-25
6	Gravel-rubble	-
7	Rubble	> 25
8	Wood	-
9	Flooded vegetation	-

uniform relative to habitat availability. Nonuniform distributions were equated with preference for specific depths and substrates.

6. Diet Study

All crappie were weighed to the nearest gram and total length was determined to the nearest millimeter. Sex of all crappie was determined by visual inspection and otoliths (sagittae) were removed for age determination. Otolith radius was measured from the center of the kernal to the anterior tip of the otolith. Distance to each annulus was measured along the radius from the center of the kernal to the proximal margin of the opaque band (Pannella 1974). Fish condition was calculated as Relative Weight (Wr), where Wr = Ws / Wt. Standard Weights were derived by Log_{10} (Ws) = -4.914 + 3.052 [Log_{10} (TL)] and Log_{10} (Ws) = -5.102 + 3.112 [Log_{10} (TL)] for black and white crappie, respectively (Anderson 1980).

Stomach samples were removed in the field by making an anterior cut at the esophagus and a posterior cut at the intestine. Stomachs were placed in 10% formalin and returned to the laboratory, where each stomach was rinsed in water and stored in 70% isopropyl alcohol prior to analysis. Food items were enumerated and identified to the lowest taxonomic unit possible (Mearns 1985). Diet classifications were based on the presence of prey type in the stomach at the time of capture. For the purposes of this paper, it was assumed that gut contents at the time of capture were representative of the principal food items of an individual. Piscivores were classified as having only fish in their stomachs; insectivores were classified as having primarily aquatic

insects and zooplankton in their stomachs; omnivores were classified as having both prey types present in their stomachs.

The Index of Relative Importance (IRI), which combines numerical, weight, and frequency of occurrence measurements of each prey item into one value, was used to rank the importance of each food item in the diet (Pinkas, Oliphant, and Iverson 1971). The combination of percentages, (number + volume) x (frequency), equals the Index of Relative Importance. The value of the IRI ranges from zero, when all values are zero, to 20,000 when all three indices are 100%.

Total length (mm) classifications were based at 2 size thresholds that are reported critical to crappie life history patterns. Growth and condition were examined in crappie above and below 150 mm total length, which is the length crappie reportedly switch from eating zooplankton and invertebrates to eating fish (Ball and Kilambi 1972). Length and condition were also compared in fish above and below 200 mm total length. Ellison (1984) reported increased mortality during summer of larger black crappie (> 200 mm) in small midwestern reservoirs. Daily ration in these fish declined during summer as a result of their failing to switch to piscivory, which resulted in increased mortality due to an "energy trap."

7. Age and Growth

All specimens were preserved with dry ice or 10% formalin and returned to the laboratory. At the laboratory, all crappie were weighed to the nearest gram and total length was determined to the nearest millimeter. Gonads were removed from a portion of adults from both

crappie populations. Sex of all crappie was determined by visual inspection and otoliths (sagittae) were removed from a subsample for age determination. Otolith radius was measured from the center of the kernal to the anterior tip of the otolith. Distance to each annulus was measured along the radius from the center of the kernal to the proximal margin of the opaque band (Pannella 1974).

Estimated total lengths at time of formation of otolith annuli were back-calculated using the direct proportion method with an intercept of zero (Lagler 1956). A general linear model determined the natural and common log length weight relationships by using the least squares method: $Log(WT) = a + b[Log(TL)]$. Analysis of covariance was used to compare regression slopes of the length weight data for each site (Snedecor and Cochran 1978). Significant differences in regression slopes were examined by contrast analysis (Zar 1974).

Population structure was examined with Proportional Stock Density (PSD). "Stock" and "quality" total length (mm) for black and white crappie were 130 and 200, respectively. Fish condition was calculated as Relative Weight (Wr), where Wr = Ws / Wt. Standard Weights (Ws) were derived by $Log_{10}(Ws) = -4.914 + 3.052[Log_{10}(TL)]$ and $Log_{10}(Ws) = -5.102 + 3.112[Log_{10}(TL)]$ for black and white crappie, respectively (Anderson 1980). Variances of sample mean relative weights were tested for equality in crappie samples of unequal size (Sokal and Rohlf 1969, p. 186). Significant differences in mean relative weights between crappie samples were determined by t-test for means of equal variances (Sokal and Rohlf 1969, p. 222) and for means of unequal variances (Ott 1977, p. 116). Gonadosomatic Index (GSI) was calculated as gonad weight/body weight X 100.

8. Genetic Structure

Preliminary fish sampling began in Copan Lake basin in March 1983, one month before filling the reservoir. The purpose was to sample founding crappie stocks in different areas to determine if electrophoresis could identify genetic markers indicating reproductive isolation. Indigenous white crappie were first collected from the Little Caney River (10W) at the crossing of Oklahoma Highway 10 on the western shore of Copan Lake (Figure 2). Concurrently, white crappie and black crappie were collected from Endacott's Pond (EP). The third collection site for white crappie was located at the south shore riprap on Copan Dam (RR). This area attracted large numbers of crappie during spawning season, and was adjacent to large "borrow" pits which were used during dam construction. During the seven years of reservoir construction, fish stocks were concentrated in these pits in the summer periods due to low water levels in the remainder of the basin.

Black crappie and white crappie were collected with barrel net traps, gill nets, and modified trap nets. White crappie were collected primarily during spring and summer of 1983. Black crappie were collected over a longer period and, for purposes of analysis, were grouped into summer and fall samples. All specimens were frozen on dry ice before being returned to the laboratory. At the laboratory all crappie were weighed to the nearest gram and total length was determined to the nearest milimeter. During dissection, sex of all crappie was determined by visual inspection and otoliths (sagittae) were removed for age determination. Otolith radius was measured from the center of the kernal to the anterior tip of the otolith. Distance to each annulus was

measured along the radius from the center of the kernal to the proximal margin of the opaque band (Pannella 1974). Fish condition was calculated as Relative Weight (Wr), where Wr = Ws / Wt. Standard Weights were derived by Log_{10} (Ws) = -4.914 + 3.052 [Log_{10} (TL)] and Log_{10} (Ws) = -5.102 + 3.112 [Log_{10} (TL)] for black and white crappie, respectively (Anderson 1980).

Separate extracts of liver, white muscle, and eye/brain from each individual were homogenized with an equal volume of buffer (0.1 M Tris, 0.001 M EDTA, and 5 X 10^{-5} M NADP, pH adjusted to 7.0 with HCl). The homogenate was centrifuged at 4° C for 15 minutes and supernatants were stored at -70° C for 3-10 weeks. This procedure resulted in no obvious decrease in enzyme activity, except in the case of Isocitrate dehydrogenase (IDH). Personnel from the Illinois Natural History Survey kindly assisted in gel interpretation of the IDH-2 locus. Supernatants were subjected to standard methods of horizontal starch-gel electrophoresis as modified from Siciliano and Shaw (1976) and Philipp et al. (1979).

A total of 30 (12%) white crappie and 10 (12%) black crappie were surveyed for variation at 38 enzymes. Polymorphic loci were defined as those in which the frequency of the common allele was less than 0.95. Analysis of genetic structure was performed with BIOSYS-1 FORTRAN program (Swofford and Selander 1981).

Allele frequencies were compared within hierarchical subdivisions by geographic location, sex, and age. In addition, variation was examined between individual fish of greater or lesser "plumpness" (relative weight) at capture, and between fish of greater or lesser

total length for age at capture. Relative weight categories were created by pooling all age groups into upper and lower 50 percentiles for each month. Consideration for seasonal variation in relative weight was made by further separating black crappie samples into summer and fall seasons, and white crappie samples into spring and summer seasons. Total length classes were created for each age group by separating individuals into upper and lower 50 percentiles for each month. In order to equalize the sample sizes, smaller samples were pooled in younger white crappie (Ages 0 and 1), older white crappie (Ages 4, 5, and 6), and older black crappie (Ages 3, 4, and 5).

9. Hybrid Study

Black and white crappie used for the electrophoresis study were collected by barrel net traps, gill nets, and modified trap nets in Copan lake during 1983. Specimens were field-identified by dorsal spine number and body coloration (Miller and Robison 1973). A total of 77 phenotypic black crappie and 235 phenotypic white crappie were captured and frozen on dry ice before being returned to the laboratory. At the laboratory, all crappie were weighed to the nearest gram and total length was determined to the nearest millimeter. During dissection, sex of all crappie was determined by visual inspection and otoliths (sagittae) were removed for age determination. Otolith radius was measured from the center of the kernal to the anterior tip of the otolith. Distance to each annulus was measured along the radius from the center of the kernal to the proximal margin of the opaque band (Pannella 1974).

Separate extracts of liver and eye/brain from each individual were subjected to standard methods of horizontal starch-gel electrophoresis

(Siciliano and Shaw 1976). Three enzymes were used to identify pure stocks of black and white crappie and their interspecific hybrids: malate dehydrogenase (MDH, E.C. 1.1.1.37), esterases (EST, E.C. 3.1.1.2), and phosphoglucoisomerase (PGI, E.C. 5.3.1.9). Electrophoretically, these enzymes were monomorphic within both species, and exhibited fixed differences between pure crappie stocks in Copan reservoir (Oakey 1986).

Total lengths and weights of hybrid crappie were averaged and compared with those of equivalent-age black and white crappie. Estimated total lengths at time of formation of otolith annuli were back-calculated using the direct proportion method (Lagler 1956) with an intercept of zero. Linear relationships of length-weight were determined for black, white, and hybrid crappie stocks with the least squares method: $Ln(WT) = a + b[Ln(TL)]$. An analysis of covariance was used to compare the regression slopes of the length-weight data for each stock (Snedecor and Cochran 1978). Relative weight (Wr) was calculated as $Wr = Ws / Wt$, where Ws and Wt represent standard weight and captured weight, respectively. Standard weights were derived by $Log_{10}(Ws) = -4.914 + 3.052\ [Log_{10}(TL)]$ and $Log_{10}(WS) = -5.102 + 3.112\ [Log_{10}(TL)]$ for black and white crappie, respectively (Anderson 1980). Gonosomatic index (GSI) was calculated as gonad weight/body weight X 100.

VI. RESULTS

1. Water Quality

Copan Reservoir reflected a high degree of spatial homogeneity with respect to certain physicochemical characteristics. The shallow mean depth

and north-south orientation of the reservoir permitted continuous physical mixing of the water column, resulting in similar water quality among sites within months. Transition between seasons was gradual and holomictic. As a result, many of the measurable water quality characteristics had little consequent effect on fish distributions.

Thermal stratification and subsequent DO limitation occurred only in Endacott's Pond (section 3, grids 13 and 14) during late summer (Figure 3). The remainder of the reservoir showed no oxygen limitations except for reduced concentrations in deep waters (Figures 4, 5, 6, 7). Reduced DO at increased depth was attributed to heterotrophic degradation of organic matter.

Total alkalinity (ppm as $CaCO_3$) showed marked fluctuations between seasons (Figure 8). Increased alkalinity was the result of increased rainfall on the watershed; reduced alkalinity corresponded to periods of drought.

The pH of surface waters remained constant among locations within months, but increased sharply at all locations in early summer (Figure 9). Increased pH during this period may have been indicative of photosynthetic utilization of CO_2 in the trophogenic zone.

The large areal expanse and shallow depths characteristic of section 5 were conducive to increased turbidity levels relative to other sections of the reservoir (Figure 10). Turbidity levels in the reservoir were correlated to rainfall; heavy precipitation in February 1985 led to dramatic increases in turbidity in all sections. The highest reading at this time was taken in the inundated river channel in section 4, and was the result of sediment load carried into the reservoir by the Little Caney River.

Measurement of ammonia (NH_3-H), nitrate-nitrite (NO_3-N+NO_2-N), and orthophosphate (PO_4) concentrations were taken at four locations in November

1984, February 1985, and June 1985 (Table 2). Ammonia exceeded detection limits only once--during June in Endacott's Pond. This increase in ammonia was probably the result of developing anoxic conditions prior to onset of stratification in this area.

Nitrogen concentrations were detectable at all locations during each sampling period. The effect of detectable nitrogen would be to reduce the importance of nitrogen-fixing blue-green algae in the phytoplankton assemblage; however, data from mid-to-late summer (often a period of nitrogen limitation in eutrophic reservoirs) is lacking.

Orthophosphate concentrations were below detectable limits in November and February, but were dectable in June. Thus, concentrations did not appear to be limited for late spring and early summer production.

The surface concentrations of lead (Pb), chromium (Cr), cadmium (Cd), zinc (Zn), nickel (Ni), and copper (Cu) were measured at four locations during August and November 1984, and February and June 1985 (Figures 11, 12, 13, 14, 15, 16). Except for Ni, all metals exceeded MATC requirements in at least one location and sampling period. However, 4-day average concentrations remained below the calculated MATC level and are presumed to pose no health threat to reservoir biota. Concentrations of Pb, Cr, Cd, and Ni were highest during February, indicating transport into the reservoir from upstream locations during periods of increased precipitation. Only two metals, Zn and Cu, were found in higher concentrations during August than in February. These peak concentrations were found in the inundated river channel in section 4, indicating transport into the reservoir despite low river discharge. The seasonal concentrations of other minor nutrients are given in Table 3.

Table 2. Seasonal concentrations (ppm) of ammonia, nitrate-nitrite, and orthophosphate at four standard locations in Copan Reservoir.

Location	Season	NH_3-H	NO_3-N+NO_2-N	PO_4
S1G7	Fall	< 0.080	0.116	< 0.050
	Winter	< 0.013	0.229	< 0.010
	Spring	< 0.100	0.234	0.046
S3G14	Fall	< 0.080	0.071	< 0.050
	Winter	< 0.013	0.152	< 0.010
	Spring	0.210	0.199	0.028
S4G10	Fall	< 0.080	0.112	< 0.050
	Winter	< 0.013	0.398	< 0.010
	Spring	< 0.100	0.328	0.026
S5G9	Fall	< 0.080	0.217	< 0.050
	Winter	< 0.013	0.360	< 0.010
	Spring	< 0.100	0.210	0.046

Table 3. Seasonal concentrations (ppm) of major anions at four standard locations in Copan Reservior.

Date	Location	Na	Ca	Mg	K	Fe
8-26-84	S1 - G7	20.7	39.26	6.2	2.7	0.94
	S3 - G14	29.1	38.39	7.1	2.7	0.60
	S4 - G10	20.7	38.52	6.5	2.8	0.82
	S5 - G9	17.4	32.16	5.7	2.4	1.73
11-24-84	S1 - G7	21.9	39.18	7.0	2.7	0.57
	S3 - G14	39.1	30.02	6.6	3.0	1.34
	S4 - G10	20.8	35.21	6.6	2.9	1.14
	S5 - G9	21.3	31.47	6.4	2.8	1.50
2-28-85	S1 - G7	19.2	26.6	5.0	2.2	3.15
	S3 - G14	19.2	27.1	5.1	2.7	4.7
	S4 - G10	12.0	17.8	5.2	4.5	15.98
	S5 - G9	10.4	17.7	4.3	3.6	12.74
6-14-85	S1 - G7	16.8	28.6	4.3	2.6	1.38
	S3 - G14	16.6	26.6	4.0	2.7	1.59
	S4 - G10	16.7	26.6	4.1	2.8	1.74
	S5 - G9	15.8	24.8	4.1	3.3	3.23

2. Plankton

The microcrustacean fauna of Copan Reservoir was comprised predominantly of calanoid copepods of the genus Diaptomus. Two families of cladocera, Sididae and Daphnidae, were most commonly represented by Diaphmasoma sp. and Daphina parvula, respectively. Rotifers were represented by three familes--Brachionidae, Testudinellidae, and Synchaetidae. Brachionus calyciflorus was the common representative of Brachionidae. The common members of Testudinellidae and Synchaetidae were Filinia sp. and Polyarthra sp., respectively.

Estimated copepod densities attained levels of about 399 individuals per liter. At these levels, cladoceran densities were approximately 200/l and rotifers accounted for about 103/l. Of the rotifers, Brachionus calyciflorus and Filinia sp. accounted for about 56/l and 33/l, respectively.

Phytoplankton taxa included the blue-green algae Anabaena sp. and Rivularia sp., the green algae Ankistrodesmus sp. and Pediastrum sp., the yellow-green algae Tribonema sp., the diatom Fragilaria sp., and the dinoflagellates Ceratium sp., and Peridinium sp. During spring and summer, the predominant taxa were Tribonema sp. and Pediastrum sp. Blue-green algae were never abundant to the exclusion of other taxa. The dinoflagellate Ceratium sp. occurred in all samples analyzed, but Peridinium sp. was only found in spring samples.

Estimated biomass, inclusive of zooplankton and phytoplankton taxa, was variable among sampling locations within and between months (Table 4). Samples contaminated with sediments were excluded from the analysis. Primary productivity does not appear to be a limiting factor to fish production in the reservoir.

Table 4. Estimated biomass (mg/l) of plankton in Copan Reservoir, May 1984-August 1985.

Date	Section 1	2	3	4	5
1984					
22 May	0.8329	0.0928	0.1379	-	0.5128
18 Jun	0.0884	0.1238	0.1715	0.1989	0.9832
21 Jul	0.3342	0.2317	0.1689	0.1503	0.2653
25 Aug	0.1556	0.2219	0.1936	-	0.1485
23 Sep	0.1149	0.1777	0.0707	0.2228	0.0672
15 Oct	0.1813	0.8479	0.0973	0.2582	-
24 Nov	0.2184	0.1989	0.1804	0.2122	0.2600
1985					
26 Jan	-	-	1.8500	-	-
16 Mar	0.2042	0.2608	0.0398	-	-
14 Apr	-	-	-	-	0.8700
24 May	0.1300	0.1777	0.1919	0.1945	0.4085
29 Jun	0.1963	0.2679	0.1530	0.3687	0.2051
11 Jul	0.1141	0.1636	2.4934	6.4016	-
8 Aug	0.1936	0.1874	0.1326	-	0.2405

3. Benthos

The paucity of benthic invertebrates in substrate samples from Copan Reservoir was probably the result of slow colonization of profundal areas and the relative inefficiency of sampling coarse substrates. The predominant taxa included the dipteran families Chironomidae and Chaoboridae. These taxa were abundant in samples from all sections of the reservoir during each season. Psychodidae and Simuliidae were dipterans of secondary importance, occurring in late spring and summer in depositional substrates common to sections 3 and 4.

Other taxa were much less important numerically relative to the dipterans. These included *Lymnaea* sp., *Gyraulus* sp. and *Physa* sp. (Gastropoda), Caenidae (Ephemeroptera), Brachycentridae and Limnaephilidae (Trichoptera), Copniidae (Plecoptera), Dytiscidae and Hydrophilidae (Coleoptera), aquatic mites (Arachnida), and Lumbricidae (Annelida).

4. Fish Populations in Copan Reservoir

a. Sampling Effort

The cumulative sampling effort (inclusive of all gear types) in Copan Reservoir during the study was 6,165 hr (Table 5). Barrel nets were used a total of 2,343 hr, and comprised 38.00% of the effort (Figure 17). Experimental gillnets were used over a period of 2,191 hr, or 35.54% of the effort. Frame nets were used a total of 1,624 hr, and represented 26.34% of the effort. Electrofishing accounted for 7 hr or 0.11% of the total effort expended on the reservoir.

In 1983, barrel nets represented 89.81% (1,428 hr) of the sampling effort (Figure 17). Barrel nets were used exclusively during the spring and summer

Table 5. Total yearly sampling effort (hr) by season of barrel nets (BN), frame nets (FN), gill nets (GN), and electroshocking.

Gear/Season	Year 1983	1984	1985	Total
Barrel nets				
Winter	0	57	116	173
Spring	129	387	0	516
Summer	952	114	0	1,066
Fall	347	0	241	588
Sum:	1428 (89.81%)	558 (20.71%)	357 (18.99%)	2,343 (38.00%)
Frame nets				
Winter	0	0	0	0
Spring	0	470	77	547
Summer	0	244	236	480
Fall	127	229	241	597
Sum:	127 (7.99%)	943 (34.99%)	554 (29.47%)	1624 (26.34%)
Gill nets				
Winter	0	120	192	312
Spring	0	220	364	584
Summer	0	439	194	633
Fall	35	412	215	662
Sum:	35 (2.20%)	1191 (44.19%)	965 (51.33%)	2191 (35.54%)
Electroshocking				
Winter	0	0	0	0
Spring	0	3	0	3
Summer	0	0	4	4
Fall	0	0	0	0
Sum:	0	3 (0.11%)	4 (0.21%)	7 (0.11%)
Annual Total	1,590 (25.79%)	2,695 (43.71%)	1,880 (30.49%)	6,165

seasons (Tables 6, 7). The bias toward barrel net use early in the study was due in part to the known efficiency with which these nets catch centrarchids and the fact that other gear types were not yet available. Multiple gear use was initiated during fall 1983 (Table 8), with frame nets and experimental gill nets accounting for 24.95% (127 hr) and 6.88% (35 hr) of the sampling effort, respectively.

Further constraints on initiating a comprehensive sampling regime of the reservoir early in the study included restricted access and surface obstructions which made travel between areas difficult. Consequently, sections 1, 2, and 3 were sampled frequently in 1983. Cumulative effort in Section 3 was 879 hr, or 54.97% of the effort expended in all sections. Section 1 received 341 hr of effort, or 21.45%. Effort in Section 2 was 278 hr or 17.48%. Sections 4 and 5 each received approximately 3% of the sampling effort.

Sampling in 1984 represented 43.71% (2,695 hr) of the cumulative effort expended during the entire study (Table 5). Four sampling methods were used, including barrel nets, frame nets, experimental gill nets, and electrofishing. Barrel nets were used a total of 550 hr, or 20.71% of the effort (Figure 17). Frame net effort accounted for 943 hr (34.99%), and experiemntal gill nets were used a total of 1,191 hr or 44.19% of the effort. Electrofishing accounted for 0.11% (3 hr) of the effort expended during 1984.

Effort was again greatest in Section 3 during winter 1983-1984, with barrel nets and gill nets contributing 105 hr or 59.32% of the effort expended that season (Table 9). Effort among sections was more consistent through the remaining seasons of 1984 (Tables 10, 11, 12). However, effort in Section 4 was minimized relative to other sections because of low catch rates earlier in the study.

Table 6. Spring 1983 sampling effort (hr) of barrel nets (BN), frame nets (FN), and gill nets within standard sampling sections.

Gear/Month	Section 1	2	3	4	5	Total
Barrel nets						
May	0	0	129	0	0	129
Sum:	0	0	129	0	0	129 (100.00%)
Frame nets						
May	0	0	0	0	0	0
Gill nets						
May	0	0	0	0	0	0
Total	0	0	129	0	0	129

Table 7. Summer 1983 sampling effort (hr) of barrel nets (BN), frame nets (FN), and gill nets (GN) within standard sampling sections.

Gear/Month	Section 1	2	3	4	5	Total
Barrel nets						
Jun	36	0	364	0	0	400
Jul	120	96	187	0	0	403
Aug	3	75	68	3	0	149
Sum:	159	171	619	3	0	952 (100.00%)
Frame nets						
Jun	0	0	0	0	0	0
Jul	0	0	0	0	0	0
Aug	0	0	0	0	0	0
Gill nets						
Jun	0	0	0	0	0	0
Jul	0	0	0	0	0	0
Aug	0	0	0	0	0	0
Total	159	171	619	3	0	952

Table 8. Fall 1983 sampling effort (hr) of barrel nets (BN), frame nets (FN), and gill nets within standard sampling sections.

Gear/Month	Section 1	2	3	4	5	Total
Barrel nets						
Sep	22	30	0	3	0	55
Oct	103	24	79	24	0	230
Nov	6	10	20	26	0	62
Sum:	131	64	99	53	0	952 (100.00%)
Frame nets						
Sep	0	0	0	0	0	0
Oct	22	18	0	0	24	64
Nov	27	25	0	0	11	63
Sum:	49	43	0	0	35	127 (24.95%)
Gill nets						
Sep	0	0	0	0	0	0
Oct	2	0	27	0	0	29
Nov	0	0	0	0	6	6
Sum:	2	0	27	0	6	35 (6.88%)
Total	182	107	126	53	41	509

Table 9. Winter 1983 sampling effort (hr) of barrel nets (BN), frame nets (FN), and gill nets within standard sampling sections.

Gear/Month	Section 1	2	3	4	5	Total
Barrel nets						
Jan	0	0	57	0	0	57
Feb	0	0	0	0	0	0
Sum:	0	0	57	0	0	57 (32.20%)
Frame nets						
Jan	0	0	0	0	0	0
Feb	0	0	0	0	0	0
Gill nets						
Jan	0	0	12	0	0	12
Feb	12	12	36	24	24	108
Sum:	12	12	48	24	24	120 (67.80%)
Total	12	12	105	24	24	177

Table 10. Spring 1984 sampling effort (hr) of barrel nets (BN), frame nets (FN), gill nets (GN), and electroshocking (SH) within standard sampling sections.

Gear/Month	Section 1	2	3	4	5	Total
Barrel nets						
Mar	54	84	96	41	48	323
Apr	0	0	6	0	0	6
May	0	12	46	0	0	58
Sum:	54	96	148	41	48	387 (35.83%)
Frame nets						
Mar	27	36	12	24	31	130
Apr	25	25	24	0	82	156
May	43	99	0	0	42	184
Sum:	95	160	36	24	155	470 (43.52%)
Gill nets						
Mar	0	6	17	0	6	29
Apr	24	8	8	0	8	48
May	46	24	24	0	49	143
Sum:	70	38	49	0	63	220 (20.37%)
Electroshocking						
Mar	1	1	1	0	0	3
Apr	0	0	0	0	0	0
May	0	0	0	0	0	0
Sum:	1	1	1	0	0	3 (0.28%)
Total	220	295	234	65	266	1080

Table 11. Summer 1984 sampling effort (hr) of barrel nets (BN), frame nets (FN), and gill nets (GN) within standard sampling sections.

Gear/Month	Section 1	2	3	4	5	Total
Barrel nets						
Jun	0	0	0	0	0	0
Jul	0	0	0	0	0	0
Aug	38	38	38	0	0	114
Sum:	38	38	38	0	0	114 (14.30%)
Frame nets						
Jun	0	19	0	0	0	19
Jul	24	31	24	0	24	103
Aug	29	29	35	0	29	122
Sum:	53	79	59	0	53	244 (30.61%)
Gill nets						
Jun	36	44	52	21	41	194
Jul	30	30	30	30	30	150
Aug	24	24	24	0	23	95
Sum:	90	98	106	51	94	439 (55.08%)
Total	181	215	203	51	147	797

Table 12. Fall 1984 sampling effort (hr) of barrel nets (BN), frame nets (FN), and gill nets (GN) within standard sampling sections.

Gear/Month	Section 1	2	3	4	5	Total
Barrel nets						
Sep	0	0	0	0	0	0
Oct	0	0	0	0	0	0
Nov	0	0	0	0	0	0
Frame nets						
Sep	0	0	0	0	0	0
Oct	24	24	25	24	0	97
Nov	25	30	25	26	26	132
Sum:	49	54	50	50	26	229 (35.73%)
Gill nets						
Sep	25	26	19	22	23	115
Oct	24	24	57	0	28	133
Nov	23	24	24	45	48	164
Sum:	72	74	100	67	99	412 (64.27%)
Total	121	128	150	117	125	641

Sampling in 1985 accounted for 30.49% (1880 hr) of the cumulative effort expended during the study (Table 5). Barrel nets were used a total of 357 hr or 18.99% of the sampling effort (Figure 17). Barrel nets were not used during spring or summer seasons when frame net and gillnet use increased (Tables 13, 14). Frame nets accounted for 29.47% (554 hr) of the effort, with gill nets representing 51.33% (965 hr). Electrofishing accounted for 4 hr or 0.21% of the effort expended during 1985.

Severe weather in winter 1984-1985 limited sampling to easily accessible areas of the reservoir. Sampling of Section 3 accounted for 92.21% of the effort expended during this season (Table 15). An attempt was made to maintain consistent effort among sections through the remaining seasons of 1985 (Tables 13, 14, 16). Because of reduced catch rates, effort expenditure in Section 4 was minimized relative to other areas.

b. Relative Abundances

A total of 11,103 fishes including 29 species were taken from Copan Reservoir during the period 1 May 1983 to 31 November 1985 (Table 17). Seven species accounted for 79.13% of the total catch. These were carp (*Carpiodes carpio*), gizzard shad (*Dorosoma cepedianum*), black bullhead (*Ictalurus melas*), bluegill (*Lepomis macrochirus*), spotted gar (*Lepisosteus oculatus*), white bass (*Morone chrysops*), and white crappie (*Pomoxis annularis*). Of the remaining species, river carpsucker (*Carpiodes carpio*), smallmouth buffalo (*Ictiobus bubalus*), bigmouth buffalo (*Ictiobus cyprinellus*), yellow bullhead (*Ictalurus natalis*), channel catfish (*I. punctatus*), green sunfish (*Lepomis cyanellus*), longear sunfish (*L. megaloits*), redear (*L. microlophus*), shortnose gar (*Lepisosteus platostomus*), largemouth bass (*Micropterus salmoides*), and

Table 13. Spring 1985 sampling effort (hr) of barrel nets (BN), frame nets (FN), gill nets (GN) within standard sampling sections.

Gear/Month	Section 1	2	3	4	5	Total
Barrel nets						
Mar	0	0	0	0	0	0
Apr	0	0	0	0	0	0
May	0	0	0	0	0	0
Frame nets						
Mar	0	0	0	0	0	0
Apr	18	18	20	0	21	77
May	0	0	0	0	0	0
Sum:	18	18	20	0	21	77 (17.46%)
Gill nets						
Mar	37	24	25	24	24	134
Apr	30	29	27	0	24	110
May	24	24	24	24	24	120
Sum:	91	77	76	48	72	364 (82.54%)
Total	109	95	96	48	93	441

Table 14. Summer 1985 sampling effort (hr) of barrel nets (BN), frame nets (FN), and gill nets (GN) and electroshocking (SH) within standard sampling sections.

Gear/Month	Section 1	2	3	4	5	Total
Barrel nets						
Jun	0	0	0	0	0	0
Jul	0	0	0	0	0	0
Aug	0	0	0	0	0	0
Frame nets						
Jun	24	24	24	24	24	120
Jul	22	22	24	24	24	116
Aug	0	0	0	0	0	0
Sum:	46	46	48	48	48	236 (54.38%)
Gill nets						
Jun	25	25	24	0	24	98
Jul	0	0	0	0	0	0
Aug	24	24	24	0	24	96
Sum:	49	49	48	0	48	194 (44.70%)
Electroshocking						
Jun	0	0	0	0	0	0
Jul	1	1	1	0	1	4
Aug	0	0	0	0	0	0
Sum:	1	1	1	0	1	4
Total	96	96	97	48	97	434

Table 15. Winter 1984-1985 sampling effort (hr) of barrel nets (BN), frame nets (FN), and gill nets (GN) within standard sampling sections.

Gear/Month	Section 1	2	3	4	5	Total
Barrel nets						
Dec	0	0	0	0	0	0
Jan	0	0	76	0	0	76
Feb	0	0	40	0	0	40
Sum:	0	0	116	0	0	116 (37.66%)
Frame nets						
Dec	0	0	0	0	0	0
Jan	0	0	0	0	0	0
Feb	0	0	0	0	0	0
Gill nets						
Dec	0	0	72	0	24	96
Jan	0	0	0	0	0	0
Feb	0	0	96	0	0	96
Sum:	0	0	168	0	24	192 (62.34%)
Total	0	0	284	0	24	308

Table 16. Fall 1985 sampling effort (hr) of barrel nets (BN), frame nets (FN), and gill nets (GN) within standard sampling sections.

Gear/Month	Section 1	2	3	4	5	Total
Barrel nets						
Sep	24	24	24	24	25	121
Oct	24	24	24	24	24	120
Nov	0	0	0	0	0	0
Sum:	48	48	48	48	49	241 (34.58%)
Frame nets						
Sep	24	24	24	24	25	121
Oct	24	24	24	24	24	120
Nov	0	0	0	0	0	0
Sum:	48	48	48	48	49	241 (34.58%)
Gill nets						
Sep	23	24	24	0	24	95
Oct	0	0	0	0	0	0
Nov	24	24	24	24	24	120
Sum:	47	48	48	24	48	215 (30.85%)
Total	143	144	144	120	146	697

Table 17. Total number of fishes in each species collected by all sampling methods, Spring 1983-Fall 1985.

	Year and Season												
	1983			1984				1985					
Species	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win	Spr	Sum	Fall	Total	%
Drum	-	-	-	5	11	12	16	-	16	14	13	87	0.8
River carpsucker	2	9	13	10	67	51	55	1	13	1	2	224	2.0
Carp	1	19	89	7	323	231	67	4	151	86	24	1,002	9.0
Gizzard shad	-	-	159	34	121	121	319	18	240	144	397	1,553	14.0
Hybrid bass	-	-	-	-	7	-	-	-	-	-	7	14	0.1
Smallmouth buffalo	13	6	-	-	2	2	37	2	38	8	9	117	1.1
Bigmouth buffalo	-	-	-	-	40	27	33	10	11	14	4	139	1.3
Blue catfish	-	-	-	-	4	30	2	-	20	15	21	92	0.8
Black bullhead	1	14	70	78	476	291	228	20	153	70	78	1,479	13.3
Yellow bullhead	-	6	7	3	109	-	4	1	-	2	1	133	1.2
Channel catfish	-	-	1	18	40	67	33	-	17	13	10	199	1.8
Brook silverside	-	-	-	-	1	-	-	-	-	1	-	2	0.02
Green sunfish	58	93	15	1	26	6	1	-	5	21	-	226	2.0
Warmouth	5	25	2	-	18	10	2	-	1	6	-	69	0.6
Orangespotted sunfish	-	24	-	-	1	-	1	-	-	10	1	37	0.3
Bluegill	83	249	177	29	328	93	53	1	13	347	23	1,396	12.6

Table 17. Continued.

Species	Year and Season											Total	%
	1983			1984				1985					
	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win	Spr	Sum	Fall		
Longear sunfish	16	56	6	-	33	6	-	-	1	31	1	150	1.4
Redear	177	139	13	-	20	4	3	5	1	23	3	388	3.5
Spotted gar	-	6	46	298	33	120	7	2	3	3	2	520	4.7
Longnose gar	-	-	-	-	-	4	-	-	-	1	-	5	0.1
Shortnose gar	3	5	9	-	6	80	4	1	3	7	-	118	1.1
Largemouth bass	-	3	6	1	28	73	8	-	7	10	2	138	1.2
White bass	-	150	140	293	194	134	64	9	29	9	35	1,057	9.5
River redhorse	-	-	-	-	-	-	-	-	-	-	1	1	0.01
Golden shiner	-	2	-	-	3	-	-	-	4	-	-	9	0.1
Logperch	-	-	2	-	1	-	-	-	-	-	-	3	0.03
White crappie	14	235	63	10	237	274	129	8	104	127	478	1,779	16.0
Black crappie	4	25	70	1	29	8	11	2	5	7	2	164	1.5
Flathead catfish	-	-	-	-	1	1	-	-	-	-	-	2	0.02
Total	364	1,073	994	788	2,159	1,645	1,077	84	835	970	1,114	11,103	
Relative Abundance (%)	3.3	9.7	9.0	7.1	19.5	14.8	9.7	0.8	7.5	8.7	10.0		

black crappie (Pomoxis nigromaculatus) were collected in sufficient numbers to be considered common components of the reservoir fish community. Drum (Aplodinotus grunniens), striped bass x white bass hybrids (Morone saxatilis x M. chrysops), blue catfish (Ictalurus furcatus), brook silverside (Labidesthes sicculus), warmouth (Lepomis gulosis), orangespotted sunfish (L. humilis), longnose gar (Lepisosteus osseus), river redhorse (Moxostoma erythrurum), golden shiner (Notemigonus crysoleucas), logperch (Percina caprodes), and flathead catfish (Pylodictus olivaris) were rare.

White crappie was the most abundant species in the reservoir, representing 16.02% of all fishes collected (Table 17). The relative abundance of white crappie remained consistently high throughout the study, accounting for 16.95%, 11.47%, and 23.88% of fishes taken in 1983, 1984, and 1985, respectively (Tables 18, 19, 20). In 1983, 49.76% of white crappie were collected in Section 3, primarily from the Endocott's Pond area. White crappie were abundant in Section 3 and Section 5 during 1984, with each area contributing 37.08% and 31.08%, respectively. In 1985, all sections contributed significantly to the white crappie catch, with 19.25% taken from Section 1, 14.23% from Section 2, 20.50% from Section 3, 19.94% from Section 4, and 26.08% from Section 5. The greatest seasonal relative abundance achieved by white crappie was 42.91% of all fishes taken in the fall of 1985. In contrast, the lowest seasonal relative abundance level, i.e. 1.27%, was in the winter 1983-1984.

Gizzard shad were also abundant in Copan Reservoir, representing 13.99% of all fishes collected (Table 17). The relative abundance of gizzard shad increased each year of the study, accounting for 6.54% of all fishes taken in 1983, 10.50% in 1984, and 26.61% in 1985 (Tables 18, 19, 20). Section 3 and Section 5 accounted for the greatest percentage of gizzard shad collected each

Table 18. Total number of fishes in each species collected in each section of Copan Reservoir by all sampling methods, May 1983 - November 1983.

Species	Section 1	2	3	4	5	Total	%
Drum	-	-	-	-	-	-	-
River carpsucker	3	1	10	1	9	24	1.0
Carp	18	15	35	1	40	109	4.5
Gizzard shad	12	6	62	8	71	159	6.5
Hybrid bass	-	-	-	-	-	-	-
Smallmouth buffalo	4	3	11	-	1	19	0.8
Bigmouth buffalo	-	-	-	-	-	-	-
Blue catfish	-	-	-	-	-	-	-
Black bullhead	11	7	12	-	55	85	3.5
Yellow bullhead	1	-	10	-	2	13	0.5
Channel catfish	-	-	-	-	1	1	0.04
Brook silverside	-	-	-	-	-	-	-
Green sunfish	5	5	156	-	-	166	6.8
Warmouth	9	6	17	-	-	32	1.3
Orangespotted sunfish	17	5	2	-	-	24	1.0
Bluegill	4	15	479	5	6	509	20.9
Longear sunfish	7	37	33	1	-	78	3.2
Redear	2	1	326	-	-	329	13.5
Spotted gar	-	1	50	1	-	52	2.1
Longnose gar	-	-	-	-	-	-	-
Shortnose gar	-	3	14	-	-	17	0.7
Largemouth bass	2	-	3	1	3	9	0.4
White bass	199	50	18	-	23	290	11.9
River redhorse	-	-	-	-	-	-	-
Golden shiner	-	-	2	-	-	2	0.1
Logperch	1	-	-	-	1	2	0.1
White crappie	85	64	205	4	54	412	17.0
Black crappie	2	11	74	4	8	99	4.1
Flathead catfish	-	-	-	-	-	-	-
Total	382	230	1,519	26	274	2,431	
Relative Abundance (%)	15.7	9.5	62.5	1.1	11.3		

Table 19. Total number of fishes in each species collected in each section of Copan Reservoir by all sampling methods, December 1983 - November 1984.

Species	Section 1	2	3	4	5	Total	%
Drum	19	10	6	8	1	44	0.8
River carpsucker	30	35	25	6	87	183	3.2
Carp	128	189	67	19	225	628	11.1
Gizzard shad	177	95	158	28	137	595	10.5
Hybrid bass	4	-	-	-	3	7	0.1
Smallmouth buffalo	20	5	7	-	9	41	0.7
Bigmouth buffalo	11	5	10	8	66	100	1.8
Blue catfish	23	2	4	1	6	36	0.6
Black bullhead	83	145	322	68	455	1,073	18.9
Yellow bullhead	4	17	31	6	58	116	2.1
Channel catfish	26	45	17	15	55	158	2.8
Brook silverside	1	-	-	-	-	1	0.02
Green sunfish	2	10	7	-	15	34	0.6
Warmouth	-	17	11	-	2	30	0.5
Orangespotted sunfish	-	1	-	-	1	2	0.04
Bluegill	23	91	285	12	92	503	8.9
Longear sunfish	8	26	4	-	1	39	0.7
Redear	-	7	19	-	1	27	0.5
Spotted gar	14	33	319	17	75	458	8.1
Longnose gar	-	-	1	-	3	4	0.07
Shortnose gar	2	25	13	11	39	90	1.6
Largemouth bass	29	21	13	2	45	110	1.9
White bass	222	110	9	10	334	685	12.1
River redhorse	-	-	-	-	-	-	-
Golden shiner	-	1	-	-	2	3	0.05
Logperch	-	-	-	1	-	1	0.02
White crappie	94	94	241	19	202	650	11.50
Black crappie	7	6	14	4	18	49	0.9
Flathead catfish	-	1	-	1	-	2	0.04
Total	926	992	1,583	236	1,932	5,669	
Relative Abundance (%)	16.3	17.5	27.9	4.2	34.1		

Table 20. Total number of fishes in each species collected in each section of Copan Reservoir by all sampling methods, December 1984 - November 1985.

Species	Section 1	2	3	4	5	Total	%
Drum	15	19	2	1	6	43	1.4
River carpsucker	2	1	1	-	13	17	0.6
Carp	59	91	43	7	65	265	8.8
Gizzard shad	122	25	182	157	313	799	26.6
Hybrid bass	-	1	-	4	2	7	0.2
Smallmouth buffalo	10	28	4	3	12	57	1.9
Bigmouth buffalo	-	-	10	-	29	39	1.3
Blue catfish	29	7	3	-	17	56	1.9
Black bullhead	56	37	150	16	62	321	10.7
Yellow bullhead	-	-	3	1	-	4	0.1
Channel catfish	17	8	7	1	7	40	1.3
Brook silverside	-	1	-	-	-	1	0.03
Green sunfish	7	3	8	3	5	26	0.9
Warmouth	2	1	3	-	1	7	0.2
Orangespotted sunfish	1	1	8	1	-	11	0.4
Bluegill	24	40	251	43	26	384	12.8
Longear sunfish	4	1	6	1	21	33	1.1
Redear	-	1	15	1	15	32	1.1
Spotted gar	-	-	4	2	4	10	0.3
Longnose gar	-	-	1	-	-	1	0.03
Shortnose gar	-	1	2	-	8	11	0.4
Largemouth bass	7	3	5	-	4	19	0.6
White bass	16	8	21	2	35	82	2.7
River redhorse	-	-	-	1	-	1	0.03
Golden shiner	-	-	-	-	4	4	0.10
Logperch	-	-	-	-	-	-	-
White crappie	138	102	147	143	187	717	23.9
Black crappie	1	1	6	-	8	16	0.5
Flathead catfish	-	-	-	-	-	-	-
Total	510	380	882	387	844	3,003	
Relative Abundance (%)	17.0	12.7	29.4	12.9	28.1		

year except 1984, when Section 1 also become an important contributor. The maximum seasonal relative abundance of 35.64% was achieved in the fall of 1985. No gizzard shad were collected in the spring or summer of 1983, and only 4.31% of all fishes taken in winter 1983-1984 were gizzard shad.

Black bullhead represented 13.32% of all fishes collected (Table 17). No trend was revealed by yearly relative abundance levels. The maximum relative abundance was achieved in 1984, when black bullhead accounted for 18.93% of the total catch (Table 19). Seasonal relative abundance levels remained significant from spring 1984 through spring 1985. These values ranged from 17.69% of the catch in summer 1984 to 23.81% in winter 1985. The lowest seasonal relative abundances were in 1983, where 0.27% and 1.30% of the total catch were in spring and summer, respectively. Section 3 and Section 5 accounted for the greatest percentage of black bullhead collected each year. In 1984, 20.34% and 23.55% of the black bullhead collected were taken from Section 3 and Section 5, respectively.

Bluegill represented 12.57% of the total catch (Table 17). This species tended to vary widely in relative abundance levels; increased relative abundances were typically associated with increased use of barrel nets in near-shore habaitats. Barrel nets were most commonly used in 1983, and bluegill accounted for 20.94% of all fishes collected during this period (Table 18). Thereafter, the relative abundance of bluegill declined to 8.87% in 1984 and 12.79% in 1985 when barrel net use was balanced with frame net and gillnet use (Tables 19, 20). The Endocott's Pond area of Section 3 accounted for the maximum densities of bluegill, and 31.53% were taken there in 1983, 18.00% in 1984, and 28.46% in 1985. The minimum seasonal relative abundance level of 1.19% occurred in winter 1984-1985, with the maximum of 35.77% in summer 1985.

White bass represented 9.52% of all fishes collected during the study (Table 17). In 1983 and 1984, white bass contributed 11.93% and 12.08% of the total catch, respectively (Tables 18, 19). However, in 1985 the relative abundance level declined to 2.73% (Table 20). Pelagic areas of sections 1, 2, and 5 consistently yielded significant catches of white bass with numbers increasing in Endacott's Pond (Section 3) during 1985. The maximum relative abundance achieved in 1983 was 52.09% in Section 1 and in 1984, a maximum relative abundance of 23.97% was again achieved in Section 1. However, the maximum relative abundance in 1985 was 4.15% in Section 5. A maximum seasonal relative abundance of 37.18% occurred in winter 1983-1984, but relative abundance of white bass declined consistently through the remaining seasons, with a minimum value of 0.93% achieved in summer 1985.

Carp were also abundant in Copan Reservoir during the study, representing 9.02% of all fishes collected (Table 17). The relative contribution of carp to the total yearly catch was 4.48%, 11.08%, and 8.82%, in 1983, 1984, and 1985, respectively (Tables 18, 19, 20). Carp were most frequently collected from sections 1, 2, and 5. The maximum relative abundance in 1983 was 14.60% in Section 5. In 1984 and 1985, Section 2 yielded relative abundance levels of 19.05% and 23.95%, respectively. The maximum seasonal relative abundance of 18.08% occurred in spring 1985.

Spotted gar represented 4.68% of the total catch (Table 17). In 1983, 2.14% of all fishes taken were spotted gar (Table 18). The relative abundance increased in 1984 to 8.08% (Table 19). Spotted gar decreased significantly in 1985, representing only 0.33% of the catch (Table 20). In 1983, evidence suggested that spotted gar were primarily restricted to Section 3, since 96.15% of the specimens was taken from Endacott's Pond. The population became more evenly distributed throughout the reservoir in 1984 before

declining to low abundance levels in 1985. In 1983, spotted gar contributed 3.29% of the catch in Section 3 and were not taken from sections 1 and 5. Similarly, spotted gar represented 20.15% of the catch in Section 3 during 1984, but were collected from all sections of the reservoir. Only 10 individuals were collected during 1985, making interpretation of relative abundance data difficult. Seasonally, the relative abundance of spotted gar increased through 1983, reaching a maximum level of 37.82% of the winter 1983-1984 catch. Relative abundances decreased progressivly through the remaining period of the study, reaching a low level of 0.18% in fall 1985.

Other species were less abundant but were taken in sufficient numbers to be of interest to anglers. These included redear sunfish, channel catfish, black crappie, and largemouth bass. Redear represented 3.49% of the total catch (Table 17), and were most commonly taken from Section 3. Like bluegill, increased relative abundance of redear was associated with increased use of barrel nets in near-shore habitats. In 1983, the relative abundance of redear was 13.53% (Table 18). Thereafter, redear accounted for 0.48% of the 1984 catch and 1.07% of the 1985 catch (Tables 19, 20). Redear were collected in each season except winter 1983-1984, reaching a maximum seasonal relative abundance of 48.63% in spring 1983, and a minimum of 0.12% in spring 1985.

Channel catfish contributed 1.79% of the total number of fishes collected during the study (Table 17). Only one individual was taken during 1983, but in 1984 and 1985 the relative abundance levels were 2.79% and 1.33%, respectively (Tables 18, 19, 20). The maximum seasonal relative abundance was 4.07% in summer 1984.

Black crappie accounted for 1.48% of all fishes taken (Table 17). The relative abundance of black crappie declined from 4.07% in 1983 to 0.86% in 1984 and 0.53% in 1985 (Tables 18, 19, 20). The seasonal maximum was 7.04% in

fall 1983; the minimum relative abundance level of 0.13% was achieved in winter 1983-1984.

Largemouth bass represented 1.24% of all fishes collectd during the study (Table 17). The species was most abundant in the 1984 catch, contributing 1.94% of all fishes taken (Table 19). The seasonal maximum of 4.44% was attained in summer 1984, when 97.26% of the largemouth bass were taken by gill net primarily from sections 1, 2, and 5 of the reservoir.

c. Catch Per Unit Effort (CPUE)

Catch per Unit Effort (fishes per net hr x 100) of frame nets and experimental gill nets exceeded that of barrel nets in nearly every season where multiple gear types were used. The only exception was winter 1984-1985, when barrel net CPUE was 34 and gillnet CPUE was 23 (Table 21). The most efficient gear type, based on CPUE, was experimental gill nets. These nets collected a seasonal maximum of 628 fishes per 100 hr in winter 1983-1984 and a minimum 173 fishes per 100 hr in summer 1985. Frame nets exceeded the CPUE of experimental gill nets in only two instances--spring 1984 and summer 1985.

Mean annual CPUE values for experimental gill nets decreased from 341.25 in 1984 to 156.25 in 1985. This decrease represented a 37.19% reduction in catch rates of offshore fish populations. In contrast, cumulative CPUE values for barrel nets and frame nets exhibited a 1.75% reduction in catch rates of near-shore fish populations during the same period. These data indicate a possible disruption of the vagile offshore fish populations that did not impinge significantly on near-shore fish populations.

CPUE data for 1983 reflect the intense use of barrel nets. Four of the six most abundant species were centrarchids (Table 22). These included bluegill, redear, green sunfish, and white crappie. Gizzard shad and white

Table 21. Seasonal CPUE (No. fishes per 100 hrs. sampling) of each type of sampling gear, Copan Reservoir.

Season	Barrel net	Frame net	Experimental gill net	Shocking
1983				
Sring	282	-	-	-
Summer	113	-	-	-
Fall	174	233	263	-
1984				
Winter	59	-	628	-
Spring	104	236	225	5,000
Summer	31	118	301	-
Fall	-	90	211	-
1985				
Winter	34	-	23	-
Spring	-	101	208	-
Summer	-	216	173	3,125
Fall	43	222	221	-

Table 22. Seasonal CPUE (No. fishes per 100 hrs. sampling) in 1983, Copan Reservoir.

Species	Season			
	Spring	Summer	Fall	Total
Drum	-	-	-	-
River carpsucker	1.55	0.95	2.55	1.51
Carp	0.78	2.00	17.49	6.86
Gizzard shad	-	-	31.24	10.00
Hybrid bass	-	-	-	-
Smallmouth buffalo	-	1.37	1.18	1.19
Bigmouth buffalo	-	-	-	-
Blue catfish	-	-	-	-
Black bullhead	0.78	1.47	13.75	5.35
Yellow bullhead	-	0.63	1.38	0.82
Channel catfish	-	-	0.20	0.06
Brook silverside	-	-	-	-
Green sunfish	44.96	9.77	2.95	10.44
Warmouth	3.88	2.63	0.39	2.01
Orangespotted sunfish	-	2.52	-	1.51
Bluegill	64.34	26.16	34.77	32.01
Longear sunfish	12.40	5.88	1.18	4.91
Redear	137.21	14.60	2.55	20.69
Spotted gar	-	0.63	9.04	3.27
Longnose gar	-	-	-	-
Shortnose gar	2.33	0.53	1.77	1.07
Largemouth bass	-	0.32	1.18	0.57
White bass	-	15.76	27.50	18.24
River redhorse	-	-	-	-
Golden shiner	-	0.21	-	0.13
Logperch	-	-	0.39	0.13
White crappie	10.85	24.68	32.02	25.91
Black crappie	3.10	2.63	13.75	6.23
Flathead catfish	-	-	-	-
Total	282.17	112.71	195.28	152.89

bass CPUE values indicated that these species were also abundant; however, in each instance CPUE increased with the use of frame nets and experimental gill nets during fall 1985. CPUE data indicate that carp, black bullhead, longear sunfish, spotted gar, and black crappie were common.

Bluegill was the most abundant species taken during 1983 (Table 22). The seasonal CPUE of bluegill was exceeded only by redear in the spring. The cumulative CPUE was 32 fishes per 100 hr, with the seasonal maximum of 64 in spring and the minimum of 26 occurring in summer.

The total 1983 CPUE of redear was about 21 fishes per 100 hr (Table 22). The seasonal maximum CPUE of 137 was achieved during spring 1983. The CPUE declined thereafter, with about 15 fishes per 100 hr taken in summer and 3 in fall.

Green sunfish were collected at a rate of about 10 individuals per 100 hr in 1983 (Table 22). Like redear, this species showed a progressive decrease in seasonal CPUE values. The maximum CPUE was 45 during spring. CPUE values for summer and fall were approximately 10 and 3, respectively.

White crappie were also abundant in the catch during 1983. The cumulative CPUE was about 26 fishes per 100 hr (Table 22). In contrast to redear and green sunfish, CPUE increased progressively each season. Approximately 11 white crappie were taken per 100 hr during spring, 25 during summer, and 32 in fall. This trend indicates the positive contribution by frame nets to the catch of white crappie.

The total CPUE of white bass in 1983 was about 18 individuals per 100 hr (Table 22). White bass were not collected during spring, but increased from about 16 in summer to 28 in fall.

Gizzard shad were collected at a rate of 10 individuals per 100 hr in 1983 (Table 22). This species did not appear in collections until fall, when

the CPUE of 31 was exceeded only by bluegill and white crappie. The appearance of gizzard shad in the catch at this time was probably due to expansion of collecting locations and the use of frame nets and experimental gill nets in association with barrel nets.

Common species which increased in the 1983 catch each season were carp, black bullhead, and spotted gar (Table 22). Black crappie CPUE was stable during spring and summer at about 3 individuals per 100 hr, but increased to approximately 14 during fall. The CPUE of longear sunfish declined each season.

The 1983 cumulative CPUE for all species was approximately 153 fishes per 100 hr (Table 22). Although only 11 species were taken during spring, the CPUE was greater than either summer or fall, when 18 and 19 species were taken, respectively. CPUE for all species in spring was 282 per 100 hr, approximately 113 in summer, and about 195 in fall.

Based on CPUE, seven species were abundant in the catch in 1984 (Table 23). These were carp, gizzard shad, black blullhead, bluegill, spotted gar, white bass, and white crappie. These data agree with the relative abundance data presented in the previous section. Common species were river carpsucker, bigmouth buffalo, channel catfish, shortnose gar, and largemouth bass.

The maximum cumulative CPUE achieved by any species during 1984 was exhibited by black bullhead. This species was collected at the rate of about 40 individuals per 100 hr during 1984 (Table 23). Black bullheads were consistently abundant each season. The maximum seasonal CPUE was 44 per 100 hr in both winter and spring, with the seasonal minimum of about 36 per 100 hr occurring in fall.

The second most abundant species taken in 1984 was white bass with a total CPUE of approximately 25 per 100 hr (Table 23). The CPUE of white bass

Table 23. Seasonal CPUE (No. fishes per 100 hrs. sampling) in 1984, Copan Reservoir.

Species	Season				
	Winter	Spring	Summer	Fall	Total
Drum	2.82	1.02	1.51	2.50	1.63
River carpsucker	5.65	6.20	6.40	8.58	6.79
Carp	3.95	29.91	28.98	10.45	23.30
Gizzard shad	19.21	11.20	15.18	49.77	22.08
Hybrid bass	-	0.65	-	-	0.26
Smallmouth buffalo	-	0.19	0.25	5.77	1.52
Bigmouth buffalo	-	3.70	3.39	5.15	3.71
Blue catfish	-	0.37	3.76	0.31	1.34
Black bullhead	44.07	44.07	36.51	35.57	39.81
Yellow bullhead	1.69	10.09	-	0.62	4.30
Channel catfish	10.17	3.70	8.41	5.15	5.86
Brook silverside	-	0.09	-	-	0.04
Green sunfish	0.56	2.41	0.75	0.16	1.26
Warmouth	-	1.67	1.25	0.31	1.11
Orangespotted sunfish	-	0.09	-	0.16	0.07
Bluegill	16.38	30.37	11.67	8.27	18.66
Longear sunfish	-	3.06	0.75	-	1.45
Redear	-	1.85	0.50	0.47	1.00
Spotted gar	168.36	3.06	15.06	1.09	16.99
Longnose gar	-	-	0.50	-	0.15
Shortnose gar	-	0.56	10.04	0.62	3.34
Largemouth bass	0.56	2.59	9.16	1.25	4.08
White bass	165.54	17.96	16.81	9.98	25.42
River redhorse	-	-	-	-	-
Golden shiner	-	0.28	-	-	0.11
Logperch	-	0.09	-	-	0.04
White crappie	5.65	21.94	34.38	20.12	24.12
Black crappie	0.56	2.69	1.00	1.72	1.82
Flathead catfish	-	0.09	0.13	-	0.07
Total	445.20	199.91	206.40	168.02	210.35

declined progressively each season, from a maximum of about 166 per 100 hr in winter to about 10 per 100 hr in fall.

The total 1984 CPUE of white crappie was approximately 24 per 100 hr (Table 23). In contrast to white bass, the CPUE of white crappie increased from about 6 per 100 hr in winter to about 22 per 100 hr in spring and 34 per 100 hr in summer. The fall CPUE of white crappie declined to about 20 per 100 hr, but was exceeded only by black bullhead and gizzard shad.

The total 1984 CPUE of gizzard shad was approximately 22 per 100 hr (Table 23). Gizzard shad increased in the catch each season. The seasonal minimum CPUE was about 19 per 100 hr in winter, increasing to about 11 in spring and 15 in summer, with the seasonal maximum of about 50 per 100 hr attained in fall.

Carp were taken at a rate of approximately 23 per 100 hr during 1984 (Table 23). Seasonal CPUE values ranged from about 4 per 100 hr in winter to about 30 in spring.

The total 1984 CPUE of bluegill was approximately 19 per 100 hr (Table 23). CPUE of bluegill was greatest in spring when use of frame nets and barrel nets was maximal. Seasonal CPUE values ranged from about 8 per 100 hr in fall to about 30 per 100 hr in spring.

Spotted gar were collected at a rate of approximately 17 per 100 hr in 1984 (Table 23). Like white bass, seasonal CPUE values declined progressively. The maximum CPUE was about 168 per 100 hr in winter, declining to about 3 per 100 hr in spring and about 1 per 100 hr in the fall. The CPUE did increase to about 15 per 100 hr during summer as spotted gar were taken from all sections of the reservoir for the first time.

Shortnose gar were a common component of the total catch in 1984. This species was collected at a rate of approximately 3 per 100 hr (Table 23).

Like spotted gar, the maximum seasonal CPUE was about 10 per 100 hr in the summer when shortnose gar were taken from all sections of the reservoir. After this, the CPUE decreased to less than 1 per 100 hr in fall.

The CPUE of other common species showed little tendency for significant seasonal fluctuations. These species were river carpsucker, bigmouth buffalo, channel catfish, and largemouth bass.

The 1984 cumulative CPUE for all species was approximately 210 individuals per 100 hr (Table 23). The cumulative seasonal maximum was about 445 per 100 hr in winter, attributable to the high CPUE values for spotted gar and white bass. Thereafter, the cumulative seasonal CPUE values were about 200 per 100 hr in spring, 206 per 100 hr in summer, and 168 per 100 hr in fall.

Based on CPUE, five species were abundant during 1985 (Table 24). These were carp, gizzard shad, black bullhead, bluegill, and white crappie. Notably absent from the list of abundant species are the vagile predator species--spotted gar and white bass. These two species declined to insignificant levels during 1985. Drum, smallmouth buffalo, bigmouth buffalo, blue catfish, channel catfish, longear sunfish, and redear were common in the 1985 catch, and exhibited near-equivalent cumulative CPUE values.

Gizzard shad attained the maximum cumulative CPUE of any species in 1985 (Table 24). Approximately 43 per 100 hr were taken during the year. Seasonal CPUE values increased progressively from about 6 per 100 hr in winter to about 57 per 100 hr in fall. These data indicate that the tendency of gizzard shad to increase in importance in 1984 continued through 1985.

The total 1985 CPUE of white crappie was approximately 38 per 100 hr (Table 24). The CPUE of white crappie increased each season. The CPUE in

Table 24. Seasonal CPUE (No. fishes per 100 hrs. sampling) in 1985, Copan Reservoir.

Species	Season				
	Winter	Spring	Summer	Fall	Total
Drum	-	3.63	3.23	1.87	2.29
River carpsucker	0.32	2.95	0.23	0.29	0.90
Carp	1.30	34.24	19.82	3.44	14.10
Gizzard shad	5.84	54.42	33.18	56.96	42.50
Hybrid bass	-	-	-	1.00	0.37
Smallmouth buffalo	0.65	8.62	1.84	1.29	3.03
Bigmouth buffalo	3.25	2.49	3.23	0.57	2.07
Blue catfish	-	4.54	3.46	3.01	2.98
Black bullhead	6.49	34.69	16.13	11.19	17.07
Yellow bullhead	0.32	-	0.46	0.14	0.21
Channel catfish	-	3.85	3.00	1.43	2.13
Brook silverside	-	-	0.23	-	0.05
Green sunfish	-	1.13	4.84	-	1.38
Warmouth	-	0.23	1.38	-	0.37
Orangespotted sunfish	-	-	2.30	0.14	0.59
Bluegill	0.32	2.95	79.95	3.30	20.43
Longear sunfish	-	0.23	7.14	0.14	1.76
Redear	1.62	0.23	5.30	0.43	1.70
Spotted gar	0.65	0.68	0.69	0.29	0.53
Longnose gar	-	-	0.23	-	0.05
Shortnose gar	0.32	0.68	1.61	-	0.59
Largemouth bass	-	1.59	2.30	0.29	1.01
White bass	2.92	6.58	2.07	5.02	4.36
River redhorse	-	-	0.14	-	0.05
Golden shiner	-	0.91	-	-	0.21
Logperch	-	-	-	-	-
White crappie	2.60	23.58	29.26	68.58	38.14
Black crappie	0.65	1.13	1.61	0.29	0.85
Flathead catfish	-	-	-	-	-
Total	27.27	189.30	223.50	159.80	159.73

winter was about 3 per 100 hr, about 24 per 100 hr in spring, about 29 per 100 hr in summer, and 69 per 100 hr in fall.

Bluegill remained important in 1985, with a cumulative CPUE of approximately 20 per 100 hr (Table 24). The seasonal maximum CPUE of about 80 per 100 hr occurred in summer, and corresponded to increased use of barrel nets.

Black bullhead and carp were collected at a rate of about 17 per 100 hr and 14 per 100 hr, respectively (Table 24). Each species maintained consistent CPUE values throughout the year.

The most significant change in CPUE data from the previous year was the extremely low catch rates of spotted gar, shortnose gar, and white bass. Total 1985 CPUE values of spotted gar and shortnose gar was less than 1 individual per 100 hr (Table 24). Although spotted gar were taken during each season, the seasonal maximum CPUE never exceeded 1 per 100 hr. The seasonal maximum CPUE of shortnose gar was about 2 per 100 hr in summer, but no individuals were collected during fall.

The cumulative 1985 CPUE of white bass was approximately 4 per 100 hr (Table 24). The seasonal maximum CPUE was about 7 per 100 hr in spring, indicating that the white bass population was continuing the decline in numbers revealed by 1984 CPUE data.

The cumulative 1985 CPUE of all species was approximately 160 per 100 hr (Table 24). The total seasonal maximum was about 224 per 100 hr in summer, with the minimum of about 27 occurring in winter.

d. Biomass (CPUE)

The total biomass taken in all gear types from the reservoir during the period of this study was 1,499,817g, or 24.3 kg/100 sampling hr (Table 25).

Table 25. Total annual biomass and CPUE biomass (grams per 100 hrs. sampling) of species collected in Copan Reservoir.

Species	Year 1983 Total	1983 CPUE	1984 Total	1984 CPUE	1985 Total	1985 CPUE	All years Total	All years CPUE
River carpsucker	3,057	192.26	20,783	771.17	4,400	234.04	28,240	458.07
Carp	25,961	1,632.77	142,565	5,289.98	74,067	3,939.73	242,593	3,935.81
Gizzard Shad	5,493	345.47	58,718	2,178.78	47,117	2,506.22	111,328	1,805.81
Black bullhead	9,349	587.99	110,422	4,097.29	39,315	2,091.22	159,086	2,580.47
Channel catfish	245	15.41	48,263	1,790.83	13,950	742.02	62,458	1,013.11
Bluegill	28,210	1,774.21	31,409	1,165.45	14,697	781.76	74,316	1,205.45
Spotted gar	18,627	1,171.51	178,968	6,640.74	6,323	336.33	203,918	3,307.67
Shortnose gar	13,115	824.84	59,700	2,215.21	12,274	652.87	85,089	1,380.19
Largemouth bass	2,842	178.74	19,111	709.13	2,703	143.78	24,656	399.94
White bass	5,137	323.08	131,092	4,864.27	17,762	944.79	153,991	2,497.83
White crappie	34,981	2,200.06	95,754	3,553.02	54,031	2,873.99	184,766	2,997.02
Black crappie	6,623	416.54	3,286	121.93	1,228	65.32	11,137	180.65
Other	52,550	3,305.03	61,829	2,294.21	43,860	2,332.99	158,239	2,566.73
Total	206,190	12,967.92	961,900	35,692.02	331,727	17,645.05	1,499,817	24,327.93

Based on biomass, carp, spotted gar, white crappie, black bullhead, and white bass were important components of the reservoir fish community. Other species with significant biomass levels included river carpsucker, gizzard shad, channel catfish, bluegill, shortnose gar, largemouth bass, and black crappie.

The cumulative biomass CPUE of carp was 3.9 kg/100 hr (Table 25). The maximum annual CPUE of about 5.3 kg/100 hr occurred in 1984. Spring yielded increased biomass of carp in 1984 and 1985, with maximum values of about 6.7 kg/100 hr and 10.6 kg/100 hr, respectively (Table 26).

Spotted gar accounted for approximately 3.3 kg/100 hr for the period of this study (Table 25), and achieved a maximum yearly value of about 6.6 kg/100 hr in 1984. Biomass of spotted gar in 1984 represented the greatest single-species CPUE. The following year, the species accounted for only about 336 g/100 hr. The maximum seasonal biomass was about 60.0 kg/100 hr in winter 1983-1984 (Table 26). Thereafter, spotted gar biomass declined progressively, reaching a minimum of about 187 g/100 hr in fall 1985.

The cumulative biomass CPUE of white bass was approximately 2.5 kg/100 hr (Table 25). The maximum yearly CPUE of about 4.9 kg/100 hr was attained in 1984. Like spotted gar, the maximum seasonal biomass of approximately 31.2 kg/100 hr occurred in winter 1983-1984 (Table 26). The minimum CPUE of white bass in 1985 was attained in summer, when the species accounted for about 388 g/100 hr. Biomass CPUE data for spotted gar and white bass is graphically illustrated in Figure 18.

Black bullheads were abundant in the reservoir, accounting for approximately 2.6 kg/100 hr for the period of this study (Table 25). The maximum yearly CPUE was about 4.1 kg/100 hr in 1984, with the seasonal maximum CPUE of about 9.3 kg/100 hr occurring in winter 1983-1984, and the minimum of about 157 g/100 hr occurring in spring 1983 (Table 26). As

Table 26. Seasonal CPUE biomass (grams per 100 hrs. sampling) of species collected in Copan Reservoir.

	Year and Season										
	1983			1984				1985			
Species	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
River carpsucker	267.44	208.61	142.63	476.84	402.31	969.39	1,227.45	60.06	836.05	38.71	51.65
Carp	511.63	531.62	3,976.42	457.63	6,763.70	6,588.96	2,526.21	262.99	10,586.62	4,842.86	796.56
Gizzard Shad	-	-	1,079.17	3,926.55	841.67	1,852.07	4,355.23	166.88	4,991.38	1,822.12	2,393.54
Black bullhead	157.36	303.05	1,230.06	9,257.63	2,931.85	4,283.56	4,404.37	738.31	4,022.22	1,877.42	1,600.43
Channel catfish	-	-	48.13	2,863.71	527.04	3,078.17	2,023.56	-	1,696.15	839.17	405.74
Bluegill	3,226.36	1,283.93	2,323.18	1,351.41	2,088.80	427.98	475.35	38.96	233.79	3,000.00	75.47
Spotted gar	-	165.97	3,349.12	60,001.70	1,349.07	6,737.64	701.40	461.04	443.31	379.03	186.94
Shortnose gar	1,697.67	341.91	1,506.88	-	78.24	6,903.64	597.97	360.39	767.57	1,792.40	-
Largemouth bass	-	120.80	332.42	57.63	674.26	1,202.26	334.63	-	125.40	458.99	22.69
White bass	-	191.81	650.49	31,167.23	3,316.30	3,438.77	1,981.75	780.52	1,321.32	388.25	1,126.68
White crappie	1,466.67	2,605.78	1,627.11	1,785.88	5,655.93	2,627.85	1,648.21	146.10	2,139.91	1,832.26	5,192.54
Black crappie	363.57	429.20	406.29	11.30	192.04	42.03	133.70	37.34	105.44	121.66	17.22
Other	15,152.71	2,779.31	1,285.66	627.12	1,964.26	2,283.06	3,324.34	1,829.87	3,540.82	2,890.32	1,444.05

relative abundance data suggested, black bullhead and carp may be described as abundant species with ubiquitous distributions within the reservoir.

White crappie accounted for approximately 2.9 kg/100 hr for the period of this study (Table 25), and achieved a maximum yearly value of about 3.5 kg/100 hr in 1984. The maximum seasonal biomass of about 5.6 kg/100 hr was taken in spring 1984; the minimum biomass of about 146 g/100 hr occurred in winter 1984-1985 (Table 26). White crappie maintained significant biomass CPUE levels throughout the study. In contrast, the CPUE of black crappie was represented by consistently low biomass levels. Figure 19 illustrates the seasonal biomass catch relationship for white crappie and black crappie.

The biomass of gizzard shad increased each year, from approximately 345 g/100 hr in 1983 to about 2.2 kg/100 hr in 1984 and about 2.5 kg/100 hr in 1985 (Table 25). Seasonal biomass CPUE levels (Table 26) fluctuate widely, but the general trend towards increasing biomass in the catch is not obscured (Figure 20).

The maximum yearly biomass CPUE, inclusive of all species, was 35.7 kg/100 hr, and occurred in 1984 (Table 25). Approximately 17.6 kg/100 hr were taken during 1985. The minimum yearly CPUE was about 12.9 kg/100 hr in 1983. Only in 1983 did the cumulative biomass of uncommon species exceed all common single-species biomass levels. This is due to increased CPUE of several centrarchid species as a result of the singular method of sampling, i.e., barrel nets.

e. Seasonal Habitat Preference (1984)

1. White crappie

In winter, white crappie were collected exclusively from habitats having even, uninterrupted substrate. White crappie were uniformly

distributed in the water column during this period ($P > 0.25$; Table 27). The largest individuals (mean TL = 268.0 mm) were taken from a depth of 2-3 m (Figure 21).

In spring, the distribution of white crappie was nonuniform across sampled substrates ($P < 0.001$; Table 28). Relative frequencies were greatest in broken, heterogeneous habitats (Figure 22). However, individuals taken from preferred habitats were small compared to less diverse habitats. The depth distribution during this period was also nonuniform ($P < 0.001$; Table 29). The greatest relative frequency occurred in the 2-3 m depth interval (Figure 21). The larger individuals were collected at 1-2 m depths.

Distributions of white crappie were nonuniform with respect to substrates ($P < 0.005$) and depths ($P < 0.005$) in summer (Tables 30, 31). Relative frequencies were greatest in broken, interrupted habitats at depths of 4-5 m (Figures 21, 22). During this period, the largest individuals were taken from preferred Habitats.

In fall, the distribution of white crappie was nonuniform relative to substrate availability ($P < 0.005$; Table 32). The greatest relative frequency occurred in habitats having broken, interrupted substrates (Figure 22). There was no difference in the sizes of white crappie collected in different substrate categories. White crappie depth distribution was nonuniform during this period ($P < 0.001$; Table 33). Relative frequencies were greatest above 3 m, especially in the 0-1 m depth interval (Figure 21). Again, no difference in mean lengths was found among depth categories.

2. White bass

In winter, white bass were associated exclusively with even, uninterrupted substrates. The distribution across sampled depths was

Table 27. Distribution of white crappie relative to depths sampled during winter 1983-1984, Copan Reservoir.

Depth interval (m)	Area sampled (m^2)	Observed frequency	Expected frequency
1-1.99	675	2	1.42
2-2.99	625	2	1.32
4-4.99	1,875	4	3.95
5-5.99	625	0	1.32
Total	3,800	8	
T(df)		1.90(3)	
		$P > 0.25$	

Table 28. Distribution of white crappie relative to substrates sampled during spring 1984, Copan Reservoir.

Substrate interval	Area sampled (m^2)	Observed frequency	Expected frequency
0-1.9	4,000	15	23.5
2-3.9	2,900	22	17.0
4-5.9	2,750	15	16.2
6-7.9	1,125	15	6.6
> 8	625	0	3.7
Total	11,400	57	
T(df)		19.02(4)	
		$P < 0.001$	

Table 29. Distribution of white crappie relative to depths sampled during spring 1984, Copan Reservoir.

Depth interval (m)	Area sampled (m^2)	Observed frequency	Expected frequency
0-0.99	1,000	12	5.9
1-1.99	3,400	17	20.0
2-2.99	2,125	30	12.5
3-3.99	1,125	0	6.6
4-4.99	1,875	8	11.0
5-5.99	625	0	3.7
6-6.99	1,250	0	7.3
Total	11,400	67	
T(df)		49.67(6)	
		P < 0.001	

Table 30. Distribution of white crappie relative to substrates sampled during summer 1984, Copan Reservoir.

Substrate interval	Area sampled (m^2)	Observed frequency	Expected frequency
0-1.9	3,125	36	37.14
2-3.9	1,250	14	14.86
4-5.9	1,875	37	22.29
6-7.9	2,500	17	29.71
Total	8,750	104	
T(df)		15.23(3)	
		P < 0.005	

Table 31. Distribution of white crappie relative to depths sampled during summer 1984, Copan Reservoir.

Depth interval (m)	Area sampled (m^2)	Observed frequency	Expected frequency
0-0.99	500	4	5.56
1-1.99	500	2	5.56
2-2.99	2,375	30	26.41
3-3.99	2,500	27	27.80
4-4.99	3,125	49	34.76
6-6.99	1,250	2	13.90
Total	10,250	114	
T(df)		20.12(5)	
		$P < 0.005$	

Table 32. Distribution of white crappie relative to substrates sampled during fall 1984, Copan Reservoir.

Substrate interval	Area sampled (m^2)	Observed frequency	Expected frequency
0-1.9	3,750	29	29.20
2-3.9	2,500	12	19.47
4-5.9	1,250	22	9.73
6-7.9	1,875	10	14.60
Total	9,375	73	
T(df)		19.79(3)	
		$P < 0.005$	

Table 33. Distribution of white crappie relative to depths sampled during fall 1984, Copan Reservoir.

Depth interval (m)	Area sampled (m^2)	Observed frequency	Expected frequency
0-0.99	500	8	4.47
1-1.99	2,250	11	20.10
2-2.99	2,750	40	24.56
3-3.99	500	1	4.47
4-4.99	3,750	38	33.50
5-5.99	2,500	16	22.33
7.7.99	625	1	5.58
Total	12,875	115	
T(df)		25.46(6)	
		$P < 0.001$	

Table 34. Distribution of white bass relative to depths sampled during winter 1983-1984, Copan Reservoir.

Depth interval (m)	Area sampled (m^2)	Observed frequency	Expected frequency
1-1.99	675	0	39.61
2-2.99	625	167	36.68
4-4.99	1,875	56	110.03
5-5.99	625	0	36.68
Total	3,800	223	
T(df)		565.83(3)	
		$P < 0.001$	

nonuniform ($P < 0.001$; Table 34). The greatest relative frequency occurred in the 2-3 m depth interval (Figure 23). Individual sizes were not different between depth categories.

The spring distribution of white bass was nonuniform across substrates ($P < 0.001$; Table 35). Relative frequencies were greatest in heterogeneous habitats (Figure 24). There were no differences in mean lengths among available substrate categories. Depth distributions were also nonuniform ($P < 0.001$; Table 36). Relative frequencies were greatest in the 2-3 m and 4-5 m depth intervals, with no difference in the size of individuals among depths (Figure 23).

Nonuniform distributions across substrates ($P < 0.001$) and depths ($P < 0.001$) occurred in summer (Tables 37, 38). The greatest relative frequency was observed in even, uninterrupted habitats at a depth of 4-5 m (Figures 23, 24). The smallest individuals were taken in association with preferred substrates; larger individuals occurred at preferred depths.

In fall, white bass were again distributed irregularly relative to substrate ($P < 0.001$; Table 39). The greatest frequency was collected in habitats having broken, heterogeneous substrates (Figure 24). There was no significant disparity in mean lengths among substrate categories. During this period, the depth distribution of white bass was nonuniform ($P < 0.001$; Table 40). The greatest frequency occurred in the 1-2 m depth interval (Figure 23). No differences in the sizes of individuals among depths was evident.

3. Spotted gar

In winter, spotted gar were taken only from habitats having even, uninterrupted substrates. The distribution relative to depth was nonuniform ($P < 0.001$; Table 41). Spotted gar were taken only from depths

Table 35. Distribution of white bass relative to substrates sampled during spring 1984, Copan Reservoir.

Substrate interval	Area sampled (m^2)	Observed frequency	Expected frequency
0-1.9	4,000	4	24.6
2-3.9	2,900	9	17.8
4-5.9	2,750	27	16.9
6-7.9	1,125	25	6.9
> 8	625	5	3.8
Total	11,400	70	
T(df)		75.50(4)	
		P < 0.001	

Table 36. Distribution of white bass relative to depths sampled during spring 1984, Copan Reservoir.

Depth interval (m)	Area sampled (m^2)	Observed frequency	Expected frequency
0-0.99	1,000	0	6.1
1-1.99	3,400	3	20.9
2-2.99	2,125	34	13.0
3-3.99	1,125	5	6.9
4-4.99	1,875	28	11.5
5-5.99	625	0	3.8
6-6.99	1,250	0	7.7
Total	11,400	70	
T(df)		91.15(6)	
		P < 0.001	

Table 37. Distribution of white bass relative to substrates sampled during summer 1984, Copan Reservoir.

Substrate interval	Area sampled (m^2)	Observed frequency	Expected frequency
0-1.9	3,125	125	81.43
2-3.9	1,250	10	32.57
4-5.9	1,875	62	48.86
6-7.9	2,500	31	65.14
Total	8,750	228	
T(df)		60.38(3)	
		P < 0.001	

Table 38. Distribution of white bass relative to depths sampled during summer 1984, Copan Reservoir.

Depth interval (m)	Area sampled (m^2)	Observed frequency	Expected frequency
0-0.99	500	2	11.22
1-1.99	500	0	11.22
2-2.99	2,375	29	53.29
3-3.99	2,500	81	56.10
4-4.99	3,125	109	70.12
6-6.99	1,250	9	28.05
Total	10,250	230	
T(df)		75.42(5)	
		P < 0.001	

Table 39. Distribution of white bass relative to substrates sampled during fall 1984, Copan Reservoir.

Substrate interval	Area sampled (m^2)	Observed frequency	Expected frequency
0-1.9	3,750	22	23.20
2-3.9	2,500	5	15.47
4-5.9	1,250	3	7.73
6-7.9	1,875	28	11.60
Total	9,375	58	
T(df)		33.23(3)	
		$P < 0.001$	

Table 40. Distribution of white bass relative to depths sampled during fall 1984, Copan Reservoir.

Depth interval (m)	Area sampled (m^2)	Observed frequency	Expected frequency
0-0.99	500	0	2.83
1-1.99	2,250	30	12.76
2-2.99	2,750	11	15.59
3-3.99	500	0	2.83
4-4.99	3,750	19	21.26
5-5.99	2,500	13	14.17
7.7.99	625	0	3.54
Total	12,875	73	
T(df)		34.20(6)	
		$P < 0.001$	

Table 41. Distribution of spotted gar relative to depths sampled during winter 1983-1984, Copan Reservoir.

Depth interval (m)	Area sampled (m^2)	Observed frequency	Expected frequency
1-1.99	675	0	51.33
2-2.99	625	0	47.53
4-4.99	1,875	244	142.60
5-5.99	625	45	47.53
Total	3,800	289	
T(df)		171.12(3)	
		$P < 0.001$	

Table 42. Distribution of spotted gar relative to substrates sampled during spring 1984, Copan Reservoir.

Substrate interval	Area sampled (m^2)	Observed frequency	Expected frequency
0-1.9	4,000	2	8.4
2-3.9	2,900	17	6.1
4-5.9	2,750	3	5.8
6-7.9	1,125	2	2.4
> 8	625	0	1.3
Total	11,400	24	
T(df)		27.07(4)	
		$P < 0.001$	

exceeding 4 m, with the greatest frequency occurring in the 4-5 m depth interval (Figure 25). Sizes of individuals collected at the various depths were similar.

Spring distributions of spotted gar were nonuniform across available substrates ($P < 0.001$; Table 42). The greatest relative frequency was observed from coarse, uninterrupted habitats (Figure 26). Although sizes were similar across substrate catagories, the largest individuals (mean TL = 460.8 mm) were taken from areas having the preferred substrate. During this period, spotted gar preferred the 0-1 m depth interval ($P < 0.001$; Table 43).

The distribution of spotted gar was nonuniform across substrates ($P < 0.001$) and depths ($P < 0.05$) in summer (Tables 44, 45). Relative frequencies were greatest in broken, interrupted habitats at depths exceeding 2 m (Figures 25, 26). Smaller individuals were found in less complex habitats in shallow water.

In fall, the distribution of spotted gar across substrates was nonuniform ($P < 0.005$; Table 46). The greatest relative frequencies were from habitats with complex substrates, especially those areas that were broken and heterogeneous (Figure 26). Spotted gar were uniformly distributed across depths during fall ($P > 0.25$; Table 47). The greatest relative frequency occurred in the 1-2 m depth interval (Figure 25).

4. Gizzard shad

In winter, gizzard shad were associated exclusively with even, uninterrupted substrates. The distribution was nonuniform across sampled depths ($P < 0.001$; Table 48), with the greatest relative frequency occurring in the 2-3 m depth interval (Figure 27). The largest individuals (mean TL = 282.5 mm) were associated with the preferred depth interval.

Table 43. Distribution of spotted gar relative to depths sampled during spring 1984, Copan Reservoir.

Depth interval (m)	Area sampled (m^2)	Observed frequency	Expected frequency
0-0.99	1,000	17	2.1
1-1.99	3,400	1	7.2
2-2.99	2,125	3	4.5
3-3.99	1,125	0	2.4
4-4.99	1,875	2	3.9
5-5.99	625	0	1.3
6-6.99	1,250	1	2.6
Total	11,400	24	
T(df)		117.17(6)	
		$P < 0.001$	

Table 44. Distribution of spotted gar relative to substrates sampled during summer 1984, Copan Reservoir.

Subsrtate interval	Area sampled (m^2)	Observed frequency	Expected frequency
0-1.9	3,125	22	41.43
2-3.9	1,250	5	16.57
4-5.9	1,875	50	24.86
6-7.9	2,500	39	33.14
Total	8,750	116	
T(df)		43.65(3)	
		$P < 0.001$	

Table 45. Distribution of spotted gar relative to depths sampled during summer 1984, Copan Reservoir.

Depth interval (m)	Area sampled (m^2)	Observed frequency	Expected frequency
0-0.99	500	2	5.76
1-1.99	500	0	5.76
2-2.99	2,375	37	27.34
3-3.99	2,500	31	28.78
4-4.99	3,125	29	35.98
6-6.99	1,250	19	14.39
Total	10,250	118	
T(df)		12.17(5)	
		$P < 0.05$	

Table 46. Distribution of spotted gar relative to substrates sampled during fall 1984, Copan Reservoir.

Substrate interval	Area sampled (m^2)	Observed frequency	Expected frequency
0-1.9	3,750	2	4.8
2-3.9	2,500	0	3.2
4-5.9	1,250	3	1.6
6-7.9	1,875	7	2.4
Total	9,375	12	
T(df)		14.88(3)	
		$P < 0.005$	

Table 47. Distribution of spotted gar relative to depths sampled during fall 1984, Copan Reservoir.

Depth interval (m)	Area sampled (m^2)	Observed frequency	Expected frequency
0-0.99	500	0	0.39
1-1.99	2,250	3	1.75
2-2.99	2,750	2	2.14
3-3.99	500	0	0.39
4-4.99	3,750	3	2.91
5-5.99	2,500	2	1.94
7.7.99	625	0	0.49
Total	12,875	10	
T(df)		2.17(6)	
		$P < 0.25$	

Table 48. Distribution of gizzard shad relative to depths sampled during winter 1983-1984, Copan Reservoir.

Depth interval (m)	Area sampled (m^2)	Observed frequency	Expected frequency
1-1.99	675	1	5.51
2-2.99	625	23	5.10
4-4.99	1,875	7	15.30
5-5.99	625	0	5.10
Total	3,800	31	
T(df)		76.11(3)	
		$P < 0.001$	

Distributions of gizzard shad were nonuniform across substrates ($P < 0.001$) and depths ($P < .001$) in spring (Tables 49, 50). Relative frequencies were greatest in coarse, uninterrupted habitats at a depth of 0-1 m, with the depth interval 1-2 m of nearly equal preference (Figures 27, 28). However, the larger individuals were taken in more complex habitats at 2-3 m depth.

In summer, the distribution of gizzard shad was nonuniform across sampled substrates ($P < 0.001$; Table 51). Relative frequencies increased in coarse, uninterrupted habitats and decreased in complex, heterogeneous habitats (Figure 28). Large individuals were collected from each substrate category. Gizzard shad were also irregularly distributed across depths ($P < 0.001$) during this period (Table 52). The preferred depth was 0-1 m, with the largest individuals occurring at greater depths (Figure 27).

Gizzard shad distributions were nonuniform across sampled substrates in fall ($P < 0.001$; Table 53). The greatest relative frequency was taken from habitats having even, uninterrupted substrates (Figure 28). As in the spring, larger individuals occurred in more complex habitats. Distributions were also nonuniform across depths ($P < 0.001$; Table 54). The preferred depth interval was 4-5 m, but larger individuals were taken from the 2-3 m depth interval (Figure 27).

5. Carp

In winter, carp were collected exclusively from even, uninterrupted habitats. The distribution across sampled depths was uniform ($P < 0.25$; Table 55). However, carp were taken only from the 2-3 m and 4-5 m depth intervals (Figure 29).

Carp distributions were nonuniform across substrates ($P < 0.001$) and depths ($P < 0.001$) during spring (Tables 56, 57). The greatest relative frequency was observed in highly dissected habitats (Figure 30), and was

Table 49. Distribution of gizzard shad relative to substrates sampled during spring 1984, Copan Reservoir.

Substrate interval	Area sampled (m^2)	Observed frequency	Expected frequency
0-1.9	4,000	5	15.1
2-3.9	2,900	25	10.9
4-5.9	2,750	8	10.4
6-7.9	1,125	5	4.2
> 8	625	0	2.4
Total	11,400	43	
T(df)		28.10(4)	
		P < 0.001	

Table 50. Distribution of gizzard shad relative to depths sampled during spring 1984, Copan Reservoir.

Depth interval (m)	Area sampled (m^2)	Observed frequency	Expected frequency
0-0.99	1,000	9	3.8
1-1.99	3,400	28	12.8
2-2.99	2,125	5	8.0
3-3.99	1,125	0	4.2
4-4.99	1,875	1	7.1
5-5.99	625	0	2.4
6-6.99	1,250	0	4.7
Total	11,400	43	
T(df)		42.83(6)	
		P < 0.001	

Table 51. Distribution of gizzard shad relative to substrates sampled during summer 1984, Copan Reservoir.

Substrate interval	Area sampled (m^2)	Observed frequency	Expected frequency
0-1.9	3,125	46	47.86
2-3.9	1,250	34	19.14
4-5.9	1,875	39	28.71
6-7.9	2,500	15	38.29
Total	8,750	134	
T(df)		29.46(3)	
		$P < 0.001$	

Table 52. Distribution of gizzard shad relative to depths sampled during summer 1984, Copan Reservoir.

Depth interval (m)	Area sampled (m^2)	Observed frequency	Expected frequency
0-0.99	500	46	8.78
1-1.99	500	0	8.78
2-2.99	2,375	39	41.71
3-3.99	2,500	14	43.90
4-4.99	3,125	80	54.88
6-6.99	1,250	1	21.95
Total	10,250	180	
T(df)		218.60(5)	
		$P < 0.001$	

Table 53. Distribution of gizzard shad relative to substrates sampled during fall 1984, Copan Reservoir.

Substrate interval	Area sampled (m^2)	Observed frequency	Expected frequency
0-1.9	3,750	204	126.80
2-3.9	2,500	67	84.53
4-5.9	1,250	19	42.27
6-7.9	1,875	27	63.40
Total	9,375	317	
T(df)		84.35(3)	
		$P < 0.001$	

Table 54. Distribution of gizzard shad relative to depths sampled during fall 1984, Copan Reservoir.

Depth interval (m)	Area sampled (m^2)	Observed frequency	Expected frequency
0-0.99	500	1	12.78
1-1.99	2,250	18	57.50
2-2.99	2,750	39	70.27
3-3.99	500	0	10.78
4-4.99	3,750	201	95.83
5-5.99	2,500	67	63.88
7.7.99	625	3	15.97
Total	12,875	329	
T(df)		190.78(6)	
		$P < 0.001$	

Table 55. Distribution of carp relative to depths sampled during winter 1983-1984, Copan Reservoir.

Depth interval (m)	Area sampled (m^2)	Observed frequency	Expected frequency
1-1.99	675	0	1.24
2-2.99	625	2	1.15
4-4.99	1,875	5	3.45
5-5.99	625	0	1.15
Total	3,800	7	
T(df)		3.73(3)	
		$P < 0.25$	

Table 56. Distribution of carp relative to substrates sampled during spring 1984, Copan Reservoir.

Substrate interval	Area sampled (m^2)	Observed frequency	Expected frequency
0-1.9	4,000	62	72.6
2-3.9	2,900	34	52.7
4-5.9	2,750	44	49.9
6-7.9	1,125	32	20.4
> 8	625	35	11.3
Total	11,400	207	
T(df)		65.28(4)	
		$P < 0.001$	

Table 57. Distribution of carp relative to depths sampled during spring 1984, Copan Reservoir.

Depth interval (m)	Area sampled (m^2)	Observed frequency	Expected frequency
0-0.99	1,000	15	18.2
1-1.99	3,400	6	61.7
2-2.99	2,125	86	38.6
3-3.99	1,125	35	20.4
4-4.99	1,875	65	34.0
5-5.99	625	0	11.3
6-6.99	1,250	0	22.7
Total	11,400	207	
T(df)		181.87(6)	
		$P < 0.001$	

Table 58. Distribution of carp relative to substrates sampled during summer 1984, Copan Reservoir.

Substrate interval	Area sampled (m^2)	Observed frequency	Expected frequency
0-1.9	3,125	58	87.50
2-3.9	1,250	25	35.00
4-5.9	1,875	115	52.50
6-7.9	2,500	47	70.00
Total	8,750	245	
T(df)		94.76(3)	
		$P < 0.001$	

correlated with increased reservoir storage allowing carp to move into newly inundated vegetation. Carp preferred the 2-3 m depth interval, although depths between 3-5 m were used extensively (Figure 29). Mean total length analysis of habitat categories showed no size-related differences in habitat selection.

The distribution of carp was nonuniform across substrates in summer ($P < 0.001$; Table 58). The greatest relative density was taken in broken, interrupted habitats (Figure 30). The largest individuals were found in more heterogeneous habitats. The depth distribution of carp was also nonuniform during this period ($P < 0.001$; Table 59). Carp preferred the 3-4 m depth interval, and the 4-5 m interval secondarily (Figure 29). A few extremely large individuals (mean TL = 423.2 mm) were taken below 6 m.

Fall distribution across sampled substrates was uniform ($P > 0.10$; Table 60). Relative frequencies were nearly equal between habitats having uninterrupted substrates and those having interrupted or heterogeneous substrates (Figure 30). The depth distribution was nonuniform ($P < 0.01$) during this period (Table 61). Relative density was greatest in the 0-1 m depth interval (Figure 29). No differences in size-related habitat preferences were apparent.

6. Black bullhead

Distribution of black bullhead was entirely associated with even, uninterrupted substrates in winter. Depth distribution during this period was nonuniform ($P < 0.001$; Table 62). Black bullhead preferred the 2-3 m depth interval (Figure 31). Smaller individuals were collected in shallow water, whereas larger individuals were taken in depths exceeding 4 m.

The distribution of black bullhead was nonuniform across substrates ($P < 0.001$) and depths ($P < 0.001$) in spring (Tables 63, 64). Relative frequencies

Table 59. Distribution of carp relative to depths sampled during summer 1984, Copan Reservoir.

Depth interval (m)	Area sampled (m^2)	Observed frequency	Expected frequency
0-0.99	500	0	12.10
1-1.99	500	2	12.10
2-2.99	2,375	50	57.46
3-3.99	2,500	89	60.49
4-4.99	3,125	99	75.61
6-6.99	1,250	8	30.24
Total	10,250	248	
T(df)		58.53(5)	
		$P < 0.001$	

Table 60. Distribution of carp relative to substrates sampled during fall 1984, Copan Reservoir.

Substrate interval	Area sampled (m^2)	Observed frequency	Expected frequency
0-1.9	3,750	17	22.00
2-3.9	2,500	19	14.67
4-5.9	1,250	4	7.33
6-7.9	1,875	15	11.00
Total	9,375	55	
T(df)		5.38(3)	
		$P < 0.10$	

Table 61. Distribution of carp relative to depths sampled during fall 1984, Copan Reservoir.

Depth interval (m)	Area sampled (m^2)	Observed frequency	Expected frequency
0-0.99	500	6	2.45
1-1.99	2,250	13	11.01
2-2.99	2,750	10	13.46
3-3.99	500	0	2.45
4-4.99	3,750	25	18.35
5-5.99	2,500	9	12.23
7.7.99	625	0	3.06
Total	12,875	63	
T(df)		15.16(6)	
		$P < 0.01$	

Table 62. Distribution of black bullhead relative to depths sampled during winter 1983-1984, Copan Reservoir.

Depth interval (m)	Area sampled (m^2)	Observed frequency	Expected frequency
1-1.99	675	1	14.03
2-2.99	625	54	12.99
4-4.99	1,875	24	38.98
5-5.99	625	0	12.99
Total	3,800	79	
T(df)		160.33(3)	
		$P < 0.001$	

Table 63. Distribution of black bullhead relative to substrates sampled during spring 1984, Copan Reservoir.

Substrate interval	Area sampled (m^2)	Observed frequency	Expected frequency
0-1.9	4,000	61	57.5
2-3.9	2,900	43	41.7
4-5.9	2,750	11	39.6
6-7.9	1,125	35	16.2
> 8	625	14	9.0
Total	11,400	164	
T(df)		45.50(4)	
		P < 0.001	

Table 64. Distribution of black bullhead relative to depths sampled during spring 1984, Copan Reservoir.

Depth interval (m)	Area sampled (m^2)	Observed frequency	Expected frequency
0-0.99	1,000	11	14.4
1-1.99	3,400	46	48.9
2-2.99	2,125	79	30.6
3-3.99	1,125	14	16.2
4-4.99	1,875	10	27.0
5-5.99	625	4	9.0
6-6.99	1,250	0	18.0
Total	11,400	164	
T(df)		109.22(6)	
		P < 0.001	

were greatest in heterogeneous habitats at a depth interval of 2-3 m (Figures 31, 32). However, these preferences are appear to be the result of habitat selection by smaller individuals.

Substrate distribution was nonuniform during summer ($P < 0.001$; Table 65). Relative frequencies were greatest in simple, uninterrupted habitats, although larger individuals were taken from broken, interrupted areas (Figure 32). The distribution across depths were also nonuniform during this period ($P < 0.001$; Table 66). black bullhead preferred the 3-4 m depth interval; no individuals were taken from depths less than 2 m (Figure 31).

The distribution across sampled substrates was nonuniform in fall ($P < 0.001$; Table 67). Bimodal preferences were evident from increased relative frequencies in even, uninterrupted habitats and heterogenous habitats (Figure 32). The fall depth distribution was also nonuniform ($P < 0.001$; Table 68). Relative densities were greatest in shallow water, particularly the 0-1 m depth interval (Figure 31).

5. Diet Study

Stomach contents were analyzed for a subsample of black crappie and white crappie from Copan lake basin. The diet of black crappie consisted mostly of invertebrates, the most significant being Cladocera and insects. Although fish did not form a major part of black crappie diet during most of the year, some shad were eaten (Tables 69, 70, 71).

The diet of small white crappie was similar to that of black crappie and consisted mostly of invertebrates, mainly Cladocera and insects. Larger white crappie also fed heavily on fish belonging to the families Clupeidae and Centrarchidae (Tables 72, 73, 74, 75). Diet overlap between smaller black and white crappie was high (Appendix).

Table 65. Distribution of black bullhead relative to substrates sampled during summer 1984, Copan Reservoir.

Substrate interval	Area sampled (m^2)	Observed frequency	Expected frequency
0-1.9	3,125	140	103.57
2-3.9	1,250	60	41.43
4-5.9	1,875	37	62.14
6-7.9	2,500	53	82.86
Total	8,750	290	
T(df)		42.07(3)	
		$P < 0.001$	

Table 66. Distribution of black bullhead relative to depths sampled during summer 1984, Copan Reservoir.

Depth interval (m)	Area sampled (m^2)	Observed frequency	Expected frequency
0-0.99	500	0	13.85
1-1.99	500	0	13.85
2-2.99	2,375	60	65.80
3-3.99	2,500	118	69.27
4-4.99	3,125	90	86.59
6-6.99	1,250	16	34.63
Total	10,250	284	
T(df)		72.66(5)	
		$P < 0.001$	

Table 67. Distribution of black bullhead relative to substrates sampled during fall 1984, Copan Reservoir.

Substrate interval	Area sampled (m^2)	Observed frequency	Expected frequency
0-1.9	3,750	106	79.20
2-3.9	2,500	35	52.80
4-5.9	1,250	2	26.40
6-7.9	1,875	55	39.60
Total	9,375	198	
T(df)		43.61(3)	
		$P < 0.001$	

Table 68. Distribution of black bullhead relative to depths sampled during fall 1984, Copan Reservoir.

Depth interval (m)	Area sampled (m^2)	Observed frequency	Expected frequency
0-0.99	500	15	9.20
1-1.99	2,250	56	41.42
2-2.99	2,750	65	50.62
3-3.99	500	0	9.20
4-4.99	3,750	46	69.03
5-5.99	2,500	54	46.02
7.7.99	625	1	11.50
Total	12,875	237	
T(df)		40.74(6)	
		$P < 0.001$	

Table 69. Percent number (% N), percent weight (% Wt.), frequency of occurrence (% F.O.), and index of relative importance (IRI) of food items in the diet of black crappie captured in Copan Reservoir during spring.

	Total length (mm)											
	91-120				121-150				151-180			
Food item	% N	% Wt.	% F.O.	IRI	% N	% Wt.	% F.O.	IRI	% N	% Wt.	% F.O.	IRI
Cladocera	54.74	43.40	66.66	6,542	82.07	79.91	83.33	13,498	80.14	54.21	60.00	8,061
Copepoda					9.74	9.58	16.66	322				
Amphipoda	0.35	0.35	32.85	23	0.15	0.35	16.00	8	0.08	0.30	21.05	8
Decapoda									0.08	9.47	20.00	191
Insecta												
Ephemeroptera	5.96	6.94	66.66	860	0.62	0.23	32.94	28	0.08	2.48	60.06	197
Odonata									0.17	0.90	19.63	21
Hemiptera					0.15	4.09	16.74	71				
Diptera	38.95	49.31	100	8,826	7.26	5.84	83.36	1,092	18.69	32.63	80.00	4,106
Osteichthyes												
Clupeidae												

Table 69. Continued.

Food item	271-300			
	% N	% Wt.	% F.O.	IRI
Cladocera				
Copepoda				
Amphipoda				
Decapoda				
Insecta				
Ephemeroptera				
Odonata				
Hemiptera				
Diptera				
Osteichthyes				
Clupeidae	100	100	100	20,000

Table 70. Percent number (% N), percent weight (% Wt.), frequency of occurrence (% F.O.), and index of relative importance (IRI) of food items in the diet of black crappie captured in Copan Reservoir during summer.

	Total length (mm)			
	121-150			
Food item	% N	% Wt.	% F.O.	IRI
Cladocera	43.4	60.27	66.67	6,912
Insecta				
Diptera	56.6	39.73	66.67	6,422

Table 71. Percent number (% N), percent weight (% Wt.), frequency of occurrence (% F.O.), and index of relative importance (IRI) of food items in the diet of black crappie captured in Copan Reservoir during fall.

	Total length (mm)											
	61-90				91-120				121-150			
Food item	% N	% Wt.	% F.O.	IRI	% N	% Wt.	% F.O.	IRI	% N	% Wt.	% F.O.	IRI
Cladocera	86.8	75.2	60.00	9,720	98.49	92.82	95.65	18,777	88.60	60.47	71.43	10,648
Copepoda					0.05	0.04	11.11	1				
Amphipoda					0.02	0.04	16.66	1	0.12	0.19	22.58	7
Insecta												
Ephemeroptera					0.07	0.29	5.55	2	0.82	1.21	35.47	72
Hemiptera					0.02	0.29	3.22	1	0.04	0.14	5.55	1
Trichoptera					0.02	0.04	16.66	1				
Diptera	13.2	24.8	40.00	1,520	1.34	1.47	56.58	159	10.35	15.12	71.42	1,819
Osteichthyes												
Clupeidae									0.04	4.51	7.03	32
Centrarchidae									0.04	18.77	7.12	131

Table 71. Continued.

Food item	Total length (mm) 151-180 % N	% Wt.	% F.O.	IRI	181-210 % N	% Wt.	% F.O.	IRI
Cladocera					99.29	98.45	100	19,774
Copepoda								
Amphipoda					0.35	0.52	100	87
Insecta								
Ephemeroptera					0.35	1.04	100	139
Hemiptera								
Trichoptera								
Diptera	100	100	100	20,000				
Osteichthyes								
Clupeidae								
Centrarchidae								

Table 72. Percent number (% N), percent weight (% Wt.), frequency of occurrence (% F.O.), and index of relative importance (IRI) of food items in the diet of white crappie captured in Copan Reservoir during spring.

	Total length (mm)											
	61-90				91-120				121-150			
Food item	% N	% Wt.	% F.O.	IRI	% N	% Wt.	% F.O.	IRI	% N	% Wt.	% F.O.	IRI
Cladocera					95.41	2.99	71.43	7,029	31.18	14.18	33.33	1,512
Copepoda					0.16	0.01	11.76	2	7.94	1.77	16.68	162
Amphipoda												
Decapoda												
Acarina												
Insecta												
Plecoptera												
Ephemeroptera	100	100	100	20,000	0.33	0.03	27.78	10	1.18	0.89	9.18	19
Odonata									0.88	6.20	16.67	118
Hemiptera												
Trichoptera												
Coleoptera												
Diptera					3.77	0.30	28.50	116	58.82	76.96	66.67	9,052
Osteichthyes												
Clupeidae					0.33	96.67	14.29	1,386				
Centrarchidae												
Scianenidae												
Unid. Fish												

Table 72. Continued.

Food item	Total length (mm) 151-180 % N	% Wt.	% F.O.	IRI	181-210 % N	% Wt.	% F.O.	IRI	211-240 % N	% Wt.	% F.O.	IRI
Cladocera	74.94	5.06	75.0	6,000	81.75	29.06	65.71	7,281	50.00	18.34	50.00	2,509
Copepoda	4.07	0.03	25.0	103	0.04	<0.01	2.86	1				
Amphipoda					0.14	0.02	8.57	1				
Decapoda	0.09	2.85	12.5	37	0.01	0.32	2.86	1				
Acarina					0.01	0.26	2.86	1				
Insecta												
Plecoptera					0.07	0.09	5.71	1				
Ephemeroptera	0.57	0.12	37.5	26	1.05	1.19	42.86	96	2.07	0.52	16.66	43
Odonata	0.09	0.43	25.0	13	0.30	0.61	20.00	18	0.69	1.16	16.66	31
Hemiptera					1.97	2.26	14.28	60				
Trichoptera					0.01	0.01	2.86	1				
Coleoptera					0.04	0.02	5.71	1				
Diptera	19.52	1.54	75.0	1,579	16.32	5.23	94.28	2,022	32.49	12.52	66.67	3,001
Osteichthyes												
Clupeidae	0.44	87.55	37.5	3,299	0.86	5.25	11.43	70	6.23	19.83	16.66	434
Centrarchidae	0.33	1.57	12.5	22	0.30	50.53	25.71	1,307	8.52	47.67	33.33	1,873
Scianenidae					0.01	0.32	3.86	1				
Unid. Fish	0.04	0.52	12.5	7	0.01	6.13	2.86	17				

Table 72. Continued.

	Total length (mm)											
	241-270				271-300				301-330			
Food item	% N	% Wt.	% F.O.	IRI	% N	% Wt.	% F.O.	IRI	% N	% Wt.	% F.O.	IRI
Cladocera					85.44	0.15	3.85	329				
Copepoda												
Amphipoda					0.88	<0.01	1.92	2				
Decapoda					0.26	1.71	3.85	7				
Acarina												
Insecta												
Plecoptera					0.08	<0.01	1.92	<1				
Ephemeroptera					3.53	0.07	7.69	28				
Odonata					0.08	0.01	1.92	<1				
Hemiptera					0.53	0.02	5.77	3	10.0	0.29	100	1,029
Trichoptera												
Coleoptera					0.17	0.02	1.92	<1				
Diptera					3.88	0.01	11.54	45				
Osteichthyes												
Clupeidae	95.12	93.61	92.9	17,529	4.94	97.74	86.54	8,886				
Centrarchidae	4.88	6.39	7.1	80	0.17	0.26	3.85	2	90.0	99.71	100	18,971
Scianenidae												
Unid. Fish												

Table 73. Percent number (% N), percent weight (% Wt.), frequency of occurrence (% F.O.), and index of relative importance (IRI) of food items in the diet of white crappie captured in Copan Reservoir during summer.

	Total length (mm)											
	61-90				91-120				121-150			
Food item	% N	% Wt.	% F.O.	IRI	% N	% Wt.	% F.O.	IRI	% N	% Wt.	% F.O.	IRI
Cladocera	89.30	91.76	100	18,106					0.06	0.02	12.5	1
Copepoda	10.29	6.47	14.31	240								
Amphipoda									0.03	0.02	20.0	1
Acarina												
Insecta												
Plecoptera									0.03	0.02	20.0	1
Ephemeroptera									0.03	0.02	20.0	1
Odonata												
Hemiptera												
Trichoptera												
Coleoptera												
Diptera	0.41	1.76	14.28	31	63.64	5.98	100	6,962	99.74	27.45	89.99	11,447
Megaloptera												
Osteichthyes												
Clupeidae									0.10	72.49	10.00	726
Centrarchidae					36.36	94.02	100	13,038				
Scianenidae												
Serranidae												
Unid. Fish												

Table 73. Continued.

Food item	Total length (mm) 151-180 % N	% Wt.	% F.O.	IRI	181-210 % N	% Wt.	% F.O.	IRI	211-240 % N	% Wt.	% F.O.	IRI
Cladocera	4.47	0.55	5.58	28								
Copepoda	0.06	0.01	14.28	1								
Amphipoda	0.01	0.01	50.00	1								
Acarina	0.01	0.01	50.00	1								
Insecta												
Plecoptera	0.02	0.01	33.33	1								
Ephemeroptera	0.01	0.01	50.00	1								
Odonata	0.01	0.56	5.26	3								
Hemiptera												
Trichoptera	0.01	0.01	50.00	1	0.36	0.09	6.67	3	0.40	<0.01	2.5	1
Coleoptera												
Diptera	95.36	77.62	83.32	14,414	80.00	2.45	68.57	5,654	86.93	2.63	55.56	4,976
Megaloptera					0.18	0.06	4.17	1				
Osteichthyes												
Clupeidae	0.03	16.69	8.31	139	8.55	51.26	51.43	3,076	9.50	91.82	62.96	6,379
Centrarchidae	0.03	5.1	7.96	43	8.73	33.57	25.72	1,088	1.19	3.76	7.47	37
Scianenidae												
Serranidae					1.45	12.04	8.59	116	1.39	1.13	3.57	9
Unid. Fish					0.73	0.53	5.55	7	0.40	0.63	6.79	7