EFFECTS OF WATER LEVEL FLUCTUATIONS ON GROWTH, RELATIVE ABUNDANCE AND STANDING CROP OF FISHES IN LAKE CARL BLACKWELL, OKLAHOMA

By

JEFFREY NELSON JOHNSON

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Central State University

Edmond, Oklahoma

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Thesis Approved:

Austin K. Andrews
Thesis Adviser

Robert C. Summerfelt

Ronald W. McNew

N. N. Durham
Dean of the Graduate College

PREFACE

The objectives of this study were to analyze fishery data on Lake Carl Blackwell to ascertain changes in species composition and correlate growth, relative abundance and standing crop of selected fishes with decreasing water levels associated with chronic drought conditions.

I wish to thank Dr. Austin K. Andrews who served as committee chairman and adviser, and Drs. Robert C. Summerfelt and Ronald McNew who served on the advisory committee. I also thank Mr. Robert Berger and the students of the Oklahoma Cooperative Fishery Unit for their assistance during field collections.

I am especially grateful to my wife, Bertha, for her enduring patience and encouragement throughout this study.

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CHAPTER I

INTRODUCTION

Natural or artificially induced water level fluctuations occur in most reservoirs and are known to have profound effects on the production and composition of fish populations.

Rising water levels provide spawning sites for certain species, and year-class strength of many reservoir fishes is related to water level at time of spawning (Walburg and Nelson 1966, Bross 1969, Von Geldern 1971, and others). Conversely, lowering water levels have an adverse effect on the year-class strength of certain fishes by destroying spawning sites and subjecting small fishes to increased predation (Shields 1957, Lantz et al. 1964, Riel 1965, Heman et al. 1969, Bennett et al. 1969). This increase in prey vulnerability can result in increased growth of piscivorous fishes. Lowering water levels can also have the effect of reducing littoral zone production of invertebrate fauna (Bennett 1954). Eschmeyer (1947, cited by Bennett 1954) suspected that growth of rough fish in fluctuating TVA reservoirs was limited by reduced littoral zone invertebrate production.

During the period 1962 through 1971, below average rainfall, high evaporative rates, and increased domestic water use in Payne County, Oklahoma resulted in nearly a five meter decline in the water level of Lake Carl Blackwell (Figure 1). Objectives of this study were to compile a complete species list and to correlate growth, relative abundance

Figure 1. Water Level (meters, msl) of Lake Carl Blackwell, Oklahoma, 1940–1971.

and standing crop of fishes in Lake Carl Blackwell with lowering water levels associated with chronic drought conditions. Existence of gill net, electro-fishing and rotenone data from collections made in 1967 and 1968 provide the background information for trend analyses with collections made in 1971. Life history studies of carp (Mauck and Summerfelt 1970), channel catfish (Jerald and Brown 1971a) and white crappie (Burris 1956) of Lake Carl Blackwell provide growth data that were incorporated with those from the 1971 collections and compared to changes in the lake water level. In addition, scale collections made in 1966, 1967, and 1968 by personnel of the Oklahoma Cooperative Fishery Unit augmented information on the growth history of these fishes during the drought period.

CHAPTER II

DESCRIPTION OF THE STUDY AREA

Lake Carl Blackwell (Figure 2) is a shallow, turbid reservoir located in the Permian redbeds of north-central Oklahoma 12.8 km west of Stillwater, Oklahoma on State Highway 51C. The earth and rock-fill dam lies in Section 10, Township 19N, Range 1E in Payne County. Dam construction on Stillwater Creek, a Works Progress Administration project, began in 1936 and was completed in 1938. Maximum surface area of approximately 1,460 ha with a volume of 7.5×10^7 m^3 was reached in 1945 at a spillway elevation of 288.4 m, msl. Fear that the dam might wash out prompted reconstruction and enlargement of the spillway in 1948 at which time the spillway was lowered to an elevation of 287.7 m, msl, reducing surface area to 1,355 ha and capacity to 6.8×10^7 m^3.

The main body of the lake lies on an east-west axis with several broad shallow arms extending north and south from the old stream channel. Maximum depth occurs in the old stream channel near the dam and the shallowest depths occur at the west end. In 1971, the gently rolling hills surrounding Lake Carl Blackwell were partially wooded but were predominately pastures of native grasses with some fields used for wheat and sorghum farming.

In 1971, the north shore of the lake had gradually sloping contours and many shallow mud flats. The south shore had numerous rocky outcroppings and fewer mud flats and the shallow west end of the lake

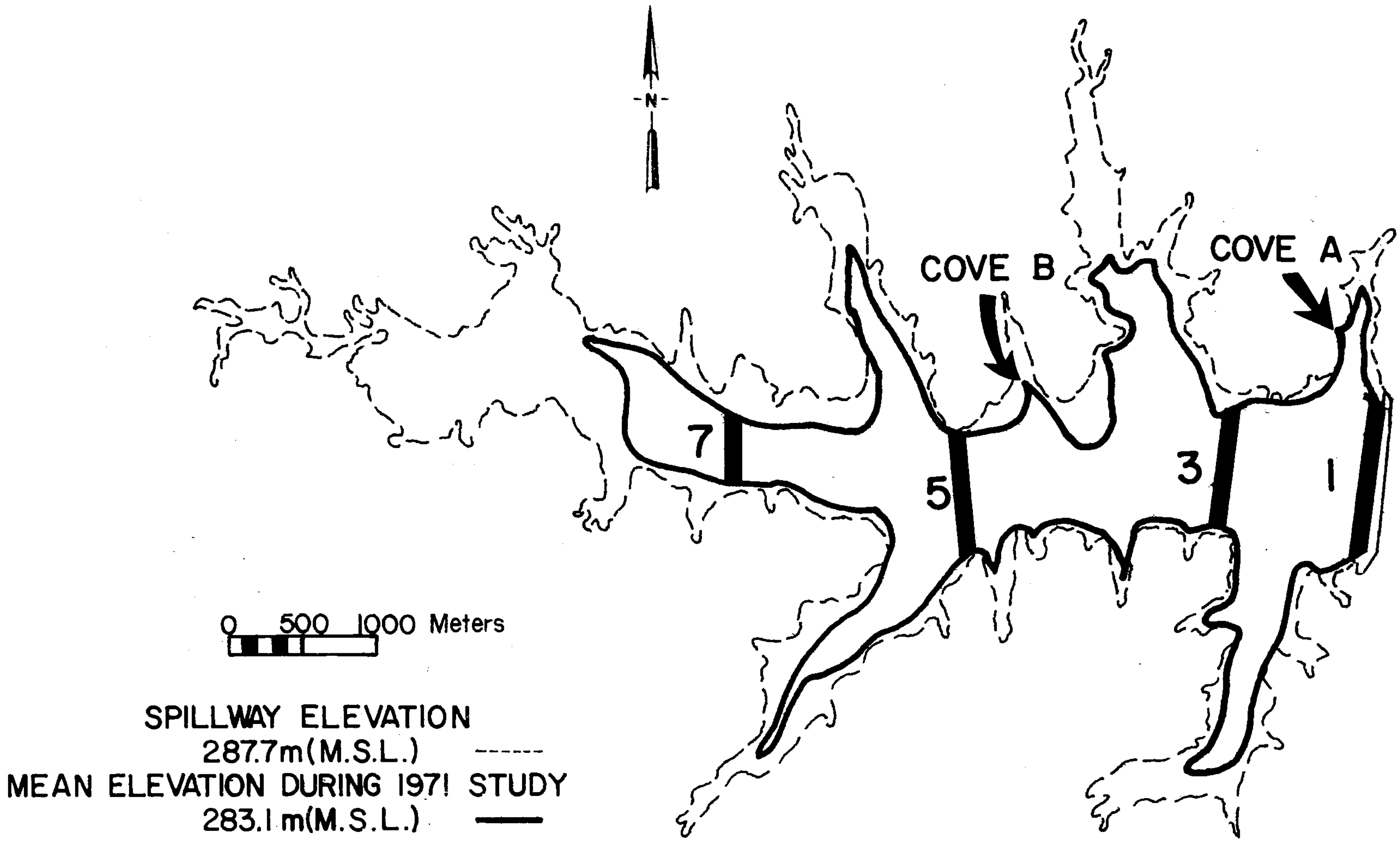

FIGURE 2. LAKE CARL BLACKWELL SHOWING TRANSECTS AND ROTENONE COVES.

contained many submerged and exposed trees and stumps. A band of exposed trees follows both sides of the old stream channel near Transect 4 and continues westward to Transect 7. The basin of the lake is generally level with the exception of the old stream channel and its tributaries. Bottom sediments are composed chiefly of fine clay particles. Sediment depth varies from approximately 0.3 to 1.0 m on the flood plain and from 1.0 to 2.3 m in the stream channel (Norton 1968).

Sampling Area 1 (Figure 2) has a gradually sloping bottom composed of fine silt and clays in deeper water and sands and coarse silts in shallower areas (Norton 1968). The reservoir had a maximum depth of about 10 m during the summer of 1971. The southern part of Area 1 has rocky shoreline with many exposed and submerged boulders.

Areas 3 and 5 are characterized by gently sloping mud or sand flats near their northern shores. Their southern shores are steeper and sandier with some areas of gravel and broken sandstone shelf rock. The northern half of Area 5 is in the belt of partially submerged trees that parallel the old stream bed.

Area 7 is very flat and shallow and is heavily silted with clays. The deepest section of Area 7 is in the old stream channel which passes near the south shore. Low water in late summer 1971 made passage to Area 7 impossible and prevented sampling.

The relatively low, unprotected shoreline, shallow depth, orientation of the reservoir, and high average wind velocities result in nearly continuous mixing of the reservoir. One consequence of mixing is the suspension of a high concentration of clay particles creating an increase in turbidity from east to west in the main body of the reservoir. For example, in 1967 turbidity ranged from a minimum of 20 Jackson units during calm days to a maximum of 180 Jackson units during periods of high wave action (Norton 1968). Following any major runoff, the western portions of the lake become quite turbid and water transparency often decreases to 10 cm or less. A maximum transparency of 157.5 cm was recorded near the dam after a series of unusually calm days in July, 1971.

A weak thermocline often develops in summer, but is quickly destroyed by wind action. Complete exhaustion of hypolimnetic oxygen occurs only irregularly during summer months when wind velocities decrease (Loomis 1951, Norton 1968).

Production of submergent and emergent macrophytes is limited by turbidity and wind action. Whenever wind sweeps across open water, it has the general effect of reducing the plant life in the water (De Gruchy 1952). Wave erosion is most prevalent on the north and east sides of the lake arms.

A periodic sequence of natural drawdowns, plant succession, and flooding is a reoccurring phenomenon of the lake as was noted during the first 12 years following initial impoundment (Loomis 1951, De Gruchy 1952). _Cyperus_ spp., _Amannia_ spp., and _Polygonium_ spp. are the predominant terrestrial macrophytes that follow the receding water line (De Gruchy 1952).

The major chemical constituents of the water of Lake Carl Blackwell are Na^+, K^+, $SO_4^=$, and Cl^- (Jenkins 1967). The lake has a moderate buffering capacity as total alkalinity averages about 120 ppm (Leonard 1950).

Primary productivity is considered to be low. Plankton production is limited by clay turbidity rather than a lack of nutrients (Leonard

1950). The lake can be classified as eutrophic, based on species diversity of net phytoplankton (Faust 1973).

Below average rainfall, high evaporation rates, and increased domestic water use in Payne County from 1962 to 1971 resulted in a continuous decline in the lake level of Carl Blackwell. A record low of 282.9 m, msl (4.9 m below spillway level) was reached 17 September, 1971. This level reduced the surface area to 667 ha which was 60 percent of the area at spillway level. The total volume was reduced to 1.9 X 10^7 m^3, only 29 percent of maximum spillway volume. The shoreline during the period of water level decline from 1962 to 1968 was characterized by barren mud flats. Littoral areas were essentially void of submergent and emergent macrophytes. A succession of terrestrial vegetation, mainly sedges (Cyperaceae), advanced as the water receded. In the spring of 1968, the lake level rose nearly two meters and flooded the shoreline vegetation. The water level declined more than a meter during the following winter and rose nearly two meters again in the spring of 1969. The water level in 1970 and 1971 declined steadily. A record low of 283.2 m, msl (5.2 m below spillway) was reached on 11 May, 1972.

CHAPTER III

HISTORY OF PAST INVESTIGATIONS

The first investigative work to include the fishes of Lake Carl Blackwell was a survey of the fishes of the Stillwater Creek drainage system by Moore and Mizelle (1939). A study of the fish populations of the lake was begun in 1947 by D. D. Poole and C. Harris (unpublished). Loomis (1951), continued the fish collections from March 1949 to March 1950 using gill nets, hoop nets, and wire traps.

Heard (1959a) reported the results of a one-year commercial fishing effort using hobbled gill nets.

Wade and Craven (1966) made a second survey of the fishes of Stillwater Creek drainage which included a partial survey of Lake Carl Blackwell. In 1967, a study was made of factors affecting the horizontal distribution of fishes of the lake (Summerfelt 1971).

Completed research on aspects of life histories of the fishes of the lake include: carp (Mauck 1970, Mauck and Summerfelt 1970), largemouth bass (Zweiacker and Brown 1971, Zweiacker 1972, Zweiacker et al. 1973), channel catfish (Jerald 1970, Jerald and Brown 1971a, 1971b), flathead catfish (Turner 1971, Turner and Summerfelt 1971a, 1971b, 1971c), white crappie (Burris 1956). Other completed research includes: distribution and occurrence of helminth parasites in fishes (Spall 1968), abundance and occurrence of algal species (Cooper 1965), productivity in relationship to turbidity (Claffey 1955), phytoplankton community structure and nutrient relationships (Faust 1973), limnological features (Leonard 1950), sediment distribution (Schrieber 1959), sediment and benthic macroinvertebrates (Norton 1968), water fluctuation on higher plants (De Gruchy 1952, 1956), and food habits of channel catfish (Heard 1959b, Jerald 1971b).

CHAPTER IV

SPECIES OCCURRENCE

Lake Carl Blackwell, a headwater reservoir, had a fish species composition that sets it apart from many Oklahoma reservoirs. The most notable difference is the absence of the gars (Lepisosteus spp.) and the buffalo fishes (Ictiobus spp.), two groups common to Oklahoma reservoirs (Hall 1949, 1952).

Moore and Mizelle (1939), in a survey of the Stillwater Creek drainage system, reported that only six species of the creek fishes were originally impounded in Lake Carl Blackwell. Their survey, made shortly after impoundment, indicated the presence of the golden shiner, red shiner, fathead minnow, black bullhead, green sunfish and orangespotted sunfish. After Moore and Mizelle's survey, several stockings of at least 10 species were made, including the above and bullhead minnow, bluegill, and black crappie. In 1955, freshwater drum was numerically the predominant species appearing in a large rotenone treatment (Kimsey 1955). Other species, by order of descending numerical abundance were: white bass, crappie, gizzard shad, channel catfish and largemouth bass. There has been only one record of gar (Lepisosteidae) in Lake Carl Blackwell. Jones (1961) reported that 50 percent of the commercial fisherman catch by weight in 1959 consisted of gar. This report is suspect since gar were not listed in any of the other collections either before or after the report by Jones.

In the present study, 20 species of fishes were collected by rotenone, gill nets, electroshocker, and shoreline seines during the study period 1 June, 1971 to 13 September, 1971 (Table 1). Absent from the present collections were the golden shiner and the fathead minnow collected by Moore and Mizelle (1939), black bullhead collected by Loomis (1951), and gar reported by Jones (1961). A search of the Zoology Department Museum, Oklahoma State University, revealed that the slim minnow and mosquitofish had been collected from Lake Carl Blackwell in 1968 and 1967, respectively, but neither of these species appeared in the 1971 collections. Also absent from the present collections was the black crappie, reported by Loomis (1951) to be the fourth most abundant fish species in the lake. The disappearance of the black crappie in Lake Carl Blackwell is consistent with the observation by several authors that white crappie become more abundant than black crappie in turbid waters (Jordan and Evermann 1902, Eschmeyer et al. 1944, Hubbs and Lagler 1947, Harlan and Speaker 1951, and Neal 1963).

The plains minnow reported by Burris (1956) to be a common food item of larger white crappies, occurred only once in the 1971 collections. Bullhead minnows introduced by early stockings (Moore and Mizelle 1939) and probably by live bait introductions is now the second most abundant minnow in the lake based on rotenone and seine collections. The most abundant minnow species collected in 1971 was the red shiner. Estimates of minnow numbers of all species from the September, 1971 cove rotenone collection revealed a numerical density of more than 2,000 ha for a shallow cove in the middle region of the lake (Cove B, Figure 2).

A 12-inch specimen of walleye was reportedly taken from the lake in

Table 1. Fish species collected from Lake Carl Blackwell, 1938 to 1971.[1]

Species		Collection Year						
		1938[2]	1949-50[3]	1959[4]	1965[5]	1967[6]	1968[6]	1971[7]
Lepisosteidae								
Gar	*Lepisosteus spp.*			X				
Clupeidae								
Gizzard shad	*Dorosoma cepedianum* (LeSueur)		X		X			X
Esocidae								
Northern pike	*Esox lucius* Linnaeus							X
Cyprinidae								
Carp	*Cyprinus carpio* Linnaeus		X		X			X
Plains minnow	*Hybognathus placitus* Girard							X
Golden shiner	*Notemigonus crysoleucas* (Mitchill)	X						
Red shiner	*Notropis lutrensis* (Baird & Girard)	X			X			X
Fathead minnow	*Pimephales promelas* Rafinesque	X						
Slim minnow	*Pimephales tenellus* (Girard)						X	
Bullhead minnow	*Pimephales vigilax* (Baird & Girard)							X
Catostomidae								
River carpsucker	*Carpiodes carpio* (Rafinesque)		X					X

Table 1 (Continued)

Species		Collection Year						
		1938[2]	1949-50[3]	1959[4]	1965[5]	1967[6]	1968[6]	1971[7]
Ictaluridae								
Channel catfish	*Ictalurus punctatus* (Rafinesque)		X					X
Black bullhead	*Ictalurus melas* (Rafinesque)	X			X			X
Yellow bullhead	*Ictalurus natalis* (LeSueur)		X					
Flathead catfish	*Pylodictis olivaris* (Rafinesque)							X
Poeciliidae								
Mosquitofish	*Gambusia affinis* (Baird & Girard)				X	X		
Percichythyidae								
White bass	*Morone crysops*				X			X
Centrarchidae								
Green sunfish	*Lepomis cyanellus* Rafinesque	X	X		X			X
Orangespotted sunfish	*Lepomis humilis* (Girard)	X			X			X
Bluegill	*Lepomis macrochirus* Rafinesque		X		X			X
Longear sunfish	*Lepomis megalotis* (Rafinesque)		X		X			X
Redear sunfish	*Lepomis microlophus* (Gunther)							X
Largemouth bass	*Micropterus salmoides* (Lacepede)		X		X			X
White crappie	*Pomoxis annularis* Rafinesque		X		X			X
Black crappie	*Pomoxis nigromaculatus* (LeSueur)		X					

Table 1 (Continued)

Species		Collection Year						
		1938[2]	1949-50[3]	1959[4]	1965[5]	1967[6]	1968[6]	1971[7]
Percidae								
Walleye	*Stizostedion vitreum* vitreum (Mitchill)							X
Sciaenidae								
Freshwater drum	*Aplodinotus grunniens* Rafinesque		X					X

[1]Names follow American Fisheries Society (Bailey et al. 1970).

[2]Moore and Mizelle (1938).

[3]Loomis (1951).

[4]Jones (1961).

[5]Wade and Craven (1966).

[6]Oklahoma State University Zoology Museum collections.

[7]Present study.

1965 with its probable introduction from bait stock from the North Canadian River (Wade and Cravens 1966). Walleye fry stockings were made by the Oklahoma Department of Wildlife Conservation in 1969, 1970, and 1971 (Hicks 1972). One 962 g specimen of walleye was captured by gill net in June, 1971.

Personnel of the Oklahoma Cooperative Fishery Unit stocked 37,000 northern pike fry (*Esox lucius*) in April, 1968. One 5.8 kg, 93.8 cm specimen of northern pike was captured by gill netting in June, 1971.

CHAPTER V

AGE AND GROWTH

Introduction

Gradually declining water levels may affect growth of reservoir fishes by increasing prey vulnerability and subsequently, growth of piscivorous fishes. The role of vulnerability of prey is discussed by Lewis (1967). Declining water levels may also reduce littoral zone production of invertebrate fauna and thereby affect the growth of some fishes.

Zweiacker et al. (1973) demonstrated that growth of Lake Carl Blackwell age 1 largemouth bass decreased during the drought years 1962-1967 while growth of age 2, 3, and 4 bass increased. It was believed that the mechanisms of increased prey vulnerability and decreased littoral zone invertebrate production best explained observed changes in growth of bass during these years of declining water level. This writer further hypothesized that growth of other fishes was correlated with the decline in the water level of Lake Carl Blackwell. Due to the existence of growth data covering 1962-1967, white crappie, channel catfish, and carp were chosen to test this hypothesis.

Materials and Methods

Fish were collected from June through September, 1971, with experimental gill nets, electroshocker boat, and rotenone. Six major reservoir areas were sampled, each presumably representing a different habitat type (Figure 2). Weight was recorded to the nearest ounce for fish heavier than 1,000 g and to the nearest gram for smaller fish. Total length was recorded to the nearest millimeter.

Scale and spine samples were taken at random from fish collected by all methods throughout the summer. Scales were taken, as recommended by Lagler (1956), on the left side of the fish, below the lateral line where the distal margin of the pectoral fin meets the body. Scales from white crappies collected in 1966, 1967, and 1968 by Oklahoma Cooperative Fishery Unit personnel were included in this portion of the study.

Impressions of at least three scales per fish were made on plastic slides with a roller press. Plastic slides, 25 mm X 75 mm X 0.5 mm, 0.75 mm, or 1.0 mm thickness were preheated on a metal surface prior to pressing following the method of Arnold (1951). Larger carp scales were softened in water prior to pressing to prevent scale breakage.

Scale measurements (in millimeters) were made using a scale projector and two or more scales were examined to verify the number of annuli on a scale. Total scale radius for crappie was obtained by measuring from the center of the focus to the most anterior portion of the scale. All total scale radius and annual measurements for carp were made along a line from the focus to the anterior-lateral margin since considerable erosion of the anterior scale margin had occurred on many of the scales. Micro-tessar lenses, sizes 72 mm and 32 mm, were used for carp and bass, respectively. Two white crappie collections were examined with a 16 mm lens and two with a 32 mm lens.

The entire left pectoral spine was removed from channel catfish by disarticulation from the locked position by a clockwise rotation. Spines were sectioned with a small power saw similar to the one described by Witt (1961). Cross sections of the spines were cut at the distal end of the basal groove to insure consistency in the location of each section. This follows the procedure outlined by Sneed (1951) and Marzolf (1955). Spine sections were then fixed to the surface of 25 X 75 mm glass slides with permount for viewing under a binocular dissecting microscope equipped with an ocular micrometer. Measurements were made along the longest spine radius.

Regression analyses were used to determine the body-scale and body-spine relationships for each collection year. Both linear and curvilinear regressions (second degree polynomial) between the scale radius in mm (X, and X^2 when fitting the curvilinear model) and body length in mm (Y) were calculated. Analysis of variance was used to test whether reduction of variance due to fitting a second degree term was significantly larger than that attributed to a linear fit (Snedecor and Cochran 1967).

All lake levels used in this study were recorded by the U.S.D.A. Agricultural Research Service, Water Conservation Structures Laboratory, Oklahoma State University. Mean annual lake levels through 1965 were calculated from daily readings. Averages from 1966 through 1971 were calculated from available readings which were usually taken on or near the first and fifteenth of each month.

Water levels for years 1962 through 1967 were chosen for calculations of correlation with growth because of the relatively steady rate of decline in water level that occurred over this period (Figure 1).

Results and Discussion

White Crappie

Body-Scale Relationship. Linear and curvilinear regressions were calculated for white crappie body-scale relationships from 98 fish collected in 1966, 244 fish collected in 1967, 26 fish collected in 1968, and 92 fish collected in 1971. Sexes were combined in the calculations. Linear and curvilinear regressions of total body length in mm (Y) on total scale radius in mm (X) were significant for all collection years ($P < 0.01$). Linear and curvilinear regression equations for the four years are:

Collection Year	Linear Regression	Linear Correlation Coefficient	Curvilinear Regression
1966	$Y = 54.2 + 0.65X$	0.94	$Y = 87.3 + 0.28X + 0.0009X^2$
1967	$Y = 61.9 + 0.60X$	0.83	$Y = 80.4 + 0.37X + 0.0006X^2$
1968	$Y = 33.9 + 1.45X$	0.94	$Y = 43.8 + 1.27X + 0.0007X^2$
1971	$Y = 19.0 + 1.5X$	0.95	$Y = 6.7 + 1.72X - 0.0006X^2$

Because reduction of variance due to inclusion of the second degree term was significant ($P < 0.01$) for the 1966 and 1967 collections, back calculations of total length at each annulus were performed using the second-degree polynomial formulae (Tables 2 and 3). Back calculations of length for the 1968 and 1971 collections were performed using Lee's formula (Tesch 1971) with the intercept values derived from the linear regressions (Tables 4 and 5).

Table 2. Mean calculated total length (mm) at end of each year of life and 95% confidence limits of white crappie in Lake Carl Blackwell collected in 1966.

Year Class	Age Group	Number of Fish	Mean Length	1	2	3	4	5	6
1965	I	35	134	107 ± 2					
1964	II	23	156	109 ± 4	138 ± 4				
1963	III	21	174	105 ± 5	130 ± 5	154 ± 5			
1962	IV	11	184	102 ± 9	128 ±12	151 ±15	171 ±18		
1961	V	7	193	101 ± 5	123 ± 9	142 ±15	160 ±18	177 ±19	
1960	VI	1	312	98	122	149	181	245	289
Unweighted Means				104	128	149	171	211	289
Mean Annual Increment				104	25	23	23	40	44
Number of Fish				98	63	40	19	8	1

Table 3. Mean calculated total length (mm) at end of each year of life and 95% confidence limits of white crappie in Lake Carl Blackwell collected in 1967.

Year Class	Age Group	Number of Fish	Mean Length	1	2	3	4	5	6	7
1966	I	21	120	104 ± 4						
1965	II	95	147	105 ± 2	135 ± 2					
1964	III	60	156	102 ± 2	130 ± 3	150 ± 3				
1963	IV	38	158	98 ± 3	121 ± 5	139 ± 5	152 ± 6			
1962	V	5	173	97 ± 5	119 ± 9	138 ± 9	159 ±18	172 ±19		
1961	VI	4	250	101 ±10	124 ±27	150 ±40	183 ±60	212 ±74	242 ±84	
1960	VII	3	250	99 ±12	130 ±16	147 ±12	160 ±11	177 ±12	195 ± 9	212 ± 9
Unweighted Means				101	126	145	163	187	218	212
Mean Annual Increment				101	26	20	20	20	24	17
Number of Fish				226	205	110	50	12	7	3

Table 4. Mean calculated total length (mm) at end of each year of life and 95% confidence limits of white crappie in Lake Carl Blackwell collected in 1968.

Year Class	Age Group	Number of Fish	Mean Length	1	2	3	4	5	6
1966	II	4	166	96 ±12	155 ±17				
1965	III	15	164	81 ± 7	124 ± 7	152 ± 6			
1964	IV	3	256	84 ±10	131 ±15	172 ±12	247 ± 2		
1963	V	2	260	77 ±39	110 ±39	137 ±52	172 ± 4	258 ±39	
1962	VI	1	262	70	117	179	221	250	262
Unweighted Means				82	127	160	213	254	262
Mean Annual Increment				82	45	40	51	58	12
Number of Fish				25	25	21	6	3	1

Table 5. Mean calculated total length (mm) at end of each year of life and 95% confidence limits of white crappie in Lake Carl Blackwell collected in 1971.

Year Class	Age Group	Number of Fish	Mean Length	1	2	3	4	5	6	7
1970	I	3	127	77 ± 8						
1969	II	31	166	69 ± 2	138 ± 4					
1968	III	23	198	67 ± 4	138 ± 9	184 ±14				
1967	IV	10	270	74 ± 7	139 ± 6	207 ±21	260 ±21			
1966	V	10	297	73 ± 9	134 ±14	192 ±38	241 ±44	278 ±42		
1965	VI	10	329	82 ± 4	143 ± 9	199 ±13	256 ±22	297 ±22	322 ±24	
1964	VII	5	330	78 ±21	128 ±25	182 ±48	236 ±73	272 ±88	306 ±83	323 ±86
Unweighted Means				74	137	192	247	283	314	323
Mean Annual Increment				74	63	56	53	38	30	17
Number of Fish				92	89	58	35	25	15	5

<u>Curvilinearity</u>. Significant curvilinear regressions for body-scale relationships of white crappie have been observed by other investigators. Burris (1956) and Brown and Jossell (1970) described this relationship for white crappie of Boomer Lake, Oklahoma, which are slow growing and considered to be stunted. Burris also found the body-scale relationship for Lake Carl Blackwell white crappie to be significantly curvilinear and attributed the cause of curvilinearity to the 127 to 178 mm fish.

Burris noted that the same size fish had low coefficients of condition and concluded that low coefficients of condition and curvilinear body-scale relationships were characteristics of stunted white crappie populations.

<u>Comparison of White Crappie Growth with Mean Annual Water Levels</u>. Growth histories from the four collection years were originally combined to form a ten-year growth history that was to be analyzed in relation to mean annual water levels during the years 1962 through 1967; however, examination of individual growth histories revealed the occurrence of Lee's phenomenon in the first year of life which could give a spurious negative correlation with water levels and mask any change in growth that might have occurred (Table 6).

Lee's phenomenon has been the subject of many studies. Four possible causes have been suggested (Ricker 1969):

(1) Incorrect procedure for back-calculations;

(2) Nonrandom sampling of the stock;

(3) Selective natural mortality;

(4) Selective fishing mortality.

The first two causes are unlikely explanations of the observed Lee's

Table 6. Mean back-calculated lengths at age 1 for white crappie (Lake Carl Blackwell).

Year Class	1966	1967	1968	1971
1970				77
1969				69
1968				67
1967				74
1966		104	96	73
1965	107	105	81	82
1964	109	102	84	78
1963	105	98	77	
1962	102	97	70	
1961	101	101		
1960	98	99		

phenomenon since each collection's back-calculated growth was based on best fit of empirical body-scale data and collections were made from a combination of sampling efforts by gill nets, trap nets, electro-fishing, and cove rotenoning. The cause of Lee's phenomenon in this case is probably selective fishing mortality of faster growing fish. As faster growing fish become vulnerable to the fishery, they are removed in greater numbers than slower growing fish. Loomis (1951) and Burris (1956) both stated that Lake Carl Blackwell supported a fair crappie fishery with good catches being made in the fall and spring of the year. The lake still supports a good spring crappie fishery as many catches of large crappie have been observed in recent years. Zweiacker (1972) reported that white crappie had the highest catch rate of all species reported in a 1969 creel survey.

A comparison of white crappie growth data from all collection years, shows several changes that occurred in growth. Mean back-calculated length at age 1 decreased 30 mm between 1966 (Table 2) and 1970 (Table 5). However, growth increments of older age fish increased such that back-calculated length of age 6 fish from the 1971 collection was 33 mm greater than age 6 fish from the 1966 collection. Also, as back-calculated growth past age 1 improved, the body-scale relationships changed from curvilinear to linear. This change supports the hypothesis of Burris that a curvilinear body-scale relationship is a characteristic of stunted white crappie populations.

Mean growth of white crappie from the present study (Table 7) is lower than both the median growth for Oklahoma waters (Table 8) and the median for U.S. reservoirs (Table 9). It is also lower than the

Table 7. Weighted mean back-calculated lengths of white crappie from combined 1966, 1967, 1968, and 1971 samples.

Year Class	Collection Year	Number of Fish	1	2	3	4	5	6	7
1970	71	3	77						
1969	71	31	69	138					
1968	71	23	67	138	184				
1967	71	10	74	139	207	260			
1966	67,68,71	35	94	140	192	241	278		
1965	66,67,68,71	155	102	134	171	256	297	322	
1964	66,67,68,71	91	102	132	153	240	272	306	323
1963	66,67,68	61	100	124	144	153	258		
1962	66,67,68	17	99	125	138	170	185	262	
1961	66,67	11	101	123	145	168	190	242	
1960	66,67	4	99	128	148	165	194	218	212
Unweighted Means			89	132	165	207	239	270	268
Mean Annual Increment			89	41	33	44	40	42	17
Number of Fish			441	438	407	384	374	278	95

Table 8. Comparison of weighted mean-back calculated lengths of Lake Carl Blackwell white crappie from 1966, 1967, 1968, and 1971 collections with data reported from other Oklahoma waters.

Locality and Reference	Mean Calculated Total Length (mm) at Annulus							
	1	2	3	4	5	6	7	8
Boomer Lake (Crawley 1954)	61	104	142	193	256	274	391	
Old Reservoirs (Hall et al. 1954)[1]	71	150	190	234	295	333	335	358
Canton Reservoir (Lewis 1972)	76	203	283	318	350	368	330	
Lake Texoma (Whiteside 1964)	86	152	208	256	295	328	353	366
Grand Lake (Jenkins 1955)	89	147	218	262	312	361		
Boomer Lake (Burris 1956)	98	129	156	179	222	254		
Boomer Lake (Brown & Jossell 1970)	99	122	141	182	229	268	343	
New Reservoirs (Hall et al. 1954)	112	229	259	312	373			
Lake Duncan (Ward 1951)[2]	149	178	191	250	310			
Median	89	150	191	250	295	328	343	
Oklahoma Average (Houser & Bross 1963)	74	150	198	249	302	335	361	381
Lake Carl Blackwell (Burris 1956)	95	123	149	175	206	224		
Lake Carl Blackwell (Present Study)	89	132	165	207	239	270	268	

[1]Greater than four years old.

[2]Total length converted from Standard length by TL = SL/0.78 (Carlander 1953).

Table 9. Comparison of weighted mean back-calculated lengths of Lake Carl Blackwell white crappie from 1966, 1967, 1968, and 1971 collections with data reported for other waters.

Locality and Reference	Mean Calculated Total Length (mm) at Annulus							
	1	2	3	4	5	6	7	8
Lake Marion, SC (Stevens 1959)	48	175	251	284	312	320	337	
Lake Moultrie, SC (Stevens 1959)	56	208	287	340	371	381	378	
Minnesota Average (Carlander 1953)	63	140	221	251	274			
Ohio Average (Carlander 1953)	66	142	198	282	307	351	391	
Median of 22 References for U. S. Waters (Carlander 1953)	70	152	208	280	305	321	376	384
Clear Lake, IO (Neal 1961)	71	145	183	208	234	272	322	
Lewis & Clark Lake, SD (Siefert 1969)	79	171	231	256	289	306	315	311
Lake Ahquabi, IO (Hennemuth 1955)	91	140	165	196				
Kentucky Lake, KY (Carter 1955)	117	201	264	302	325			
Pymatuming Lake, IO (Marcy 1954)	121	157	199	234	251	268	284	
Shallow, turbid, Iowa Lakes (Mayhew 1965)	178	191	198	208	241	279		
Median	71	157	208	256	289	306	337	
Lake Carl Blackwell (Present Study)	89	132	165	207	239	270	268	

Oklahoma average (Houser and Bross 1963), although total length at end of the first year of life is greater.

Although the occurrence of Lee's phenomenon precluded a correlative comparison of growth with mean annual water levels, the change in growth of crappies since 1960 suggests a causal relationship with water levels. Reduced limnetic production with declining water level could have accounted for the decrease in growth of age 1 crappies from 107 mm during 1965 to 77 mm during 1971 (Table 6). Also, increased growth of crappies beyond age 1 may have resulted from an increase in vulnerability of prey fishes to the piscivorous crappies during the period of water level decline.

Fluctuating water levels have been found by other investigators to have varying effects on crappie growth and year-class strength. Johnson (1945) observed that low water levels retarded the growth of white crappies in Lake Greenwood, Indiana. Extremely low water levels were recorded in three California reservoirs prior to development of stunted crappie populations in each reservoir (Geibel 1962). In Oklahoma, a 2.4 m drop in water level of Lake Spavinaw, from 1951 through 1953 had the effect of retarding crappie growth (Jackson 1957). Other investigators have found little relationship between water level and growth of white crappies. Neal (1963) found no correlation between mean annual water levels and crappie growth. No correlation between short-term fluctuations in Lake Keystone water levels and white crappie growth could be demonstrated by Al Rawi (1971), although he believed that additional data might provide such a correlation.

Channel Catfish

Body-Spine Relationship. Linear and curvilinear regressions for body-spine relationship were calculated from 63 channel catfish collected in 1971. Linear and curvilinear regressions are both significant ($P < 0.005$). Linear regression of total body length in mm (Y) on total spine radius in mm (X) is: $Y = -131.3 + 3.3X$ with a correlation coefficient of 0.93. Curvilinear regression is: $Y = 141.0 - 0.98X + 0.016X^2$. Reduction of variance due to curvilinearity is significant ($P < 0.005$).

Back calculations of length at each annulus for the 1971 collection were performed using the second-degree polynomial formula (Table 10). Sexes were combined in the calculation of a mean length at age as Jerald and Brown (1971) found no significant difference in growth between the sexes for Lake Carl Blackwell channel catfish.

A significant ($P < 0.005$) curvilinear body-spine relationship for Lake Carl Blackwell channel catfish was also described by Jerald and Brown, although they used the linear relationship in back-calculations.

Jerald and Brown noted that back-calculated lengths at annulus 1 decreased as they were calculated from successively younger age groups. They attributed reverse Lee's phenomenon to actual changes in growth and suggested a relationship between declining lake levels and decreased growth of age 1 fish. Their correlation of growth at age 1 with mean annual lake levels was nonsignificant, but they suggested that further study might be successful in demonstrating the correlation.

The absence of a negative Lee's phenomenon in the back-calculated growth data from the 1971 collections (Table 10) led to an investigation of possible causes for the phenomenon observed by Jerald and Brown. If the phenomenon resulted from actual changes in growth of channel

Table 10. Mean back calculated total length (mm) at end of each year of life of Lake Carl Blackwell channel catfish collected in 1971.

Year Class	Age Group	Number of Fish	Mean Length	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1970	1	1	200	137														
1969	2	4	172	128	149													
				± 3	±24													
1968	3	7	168	127	138	155												
				± 1	± 6	±12												
1967	4	7	214	131	151	172	197											
				± 4	± 9	±18	±25											
1966	5	7	240	128	137	160	182	216										
				± 4	± 8	±12	±10	±11										
1965	6	5	241	128	140	163	187	212	239									
				± 4	± 7	±11	±25	±30	±31									
1964	7	4	242	127	141	154	168	184	202	239								
				± 1	±15	±16	±13	±15	± 7	±13								
1963	8	2	244	127	134	143	155	174	191	214	250							
				± 2	±26	±34	±26	±11	± 9	± 6	±60							
1962	9	2	362	128	132	147	162	172	185	213	270	302						
				± 2	±17	±17	±36	±54	±82	±11	±105	±114						
1961	10	6	391	128	134	146	157	168	190	219	250	288	354					
				± 2	± 7	±10	±13	±17	±17	±23	±28	±46	±86					
1960	11	9	472	126	129	138	153	173	195	227	268	319	374	423				
				± 0	± 3	± 4	± 5	±12	±17	±20	±31	±46	±57	±64				
1959	12	4	492	126	135	144	151	162	176	194	218	260	310	363	416			
				±11	± 8	±12	±15	±19	±14	±16	±21	±27	±58	±89	±107			
1958	13	1	345	127	129	135	143	153	161	176	189	216	236	255	295	311		
1956	15	3	496	127	129	138	151	164	180	204	235	256	283	324	345	364	406	450
				± 2	± 2	± 9	±29	±39	±57	±86	±131	±121	±95	±113	±98	±103	±112	±116
Unweighted Means				128	137	150	164	178	191	211	240	274	311	342	352	338	406	560
Mean Annual Increment				128	9	14	15	17	17	26	33	35	44	42	36	18	42	44
Number of Fish				62	61	57	50	43	36	31	27	25	23	17	8	4	3	3

catfish, it should have been apparent in both studies. Otherwise, sampling bias or selection of an improper back-calculation method might cause the phenomenon. Ricker (1969), in a discussion of the effects of size-selective mortality and sampling bias on estimates of growth, indicates that sampling bias does not produce a negative Lee's phenomenon. Therefore, it is believed that the selection of a linear back-calculation method for data that were curvilinear produced the phenomenon. Back-calculated length at age for Jerald and Brown's data were recalculated using their second-degree polynomial formula. The recalculated growth increments show no reverse Lee's phenomenon for age 1 fish (Table 11) suggesting that the reverse Lee's found by Jerald and Brown may be attributed to use of the linear method of back-calculation when the curvilinear method was appropriate.

Comparison of Channel Catfish Growth with Mean Annual Water Levels. Correlation coefficients for mean annual water levels for the years 1962 through 1967 with growth increments in the first eight years of life were calculated for both the present study and the recalculated data of Jerald and Brown. No significant correlations with water level were found for growth calculated from the present study, although all correlation coefficients were negative (Table 12). Significant negative correlations were found for growth increments with water levels in years 2, 3, and 6 for recalculated data from Jerald and Brown (Table 13). The regressions for the relationship between year of growth (Y) and mean annual lake level (X) are:

Table 11. Mean back calculated total length (mm) at end of each year of life of Lake Carl Blackwell channel catfish collected by Jerald (1970). Data are recalculated using Jerald's derived second-degree body-spine relationship.

Year Class	Age Group	Number of Fish	Mean Length	1	2	3	4	5	6	7	8	9	10	11	12	13
1966	2	1		149	188											
1965	3	5		146	163	191										
				± 0	±13	±17										
1964	4	21		146	155	176	200									
				± 0	± 3	± 4	± 7									
1963	5	34		146	154	173	196	222								
				± 0	± 3	± 5	± 8	±11								
1962	6	52		146	153	169	187	206	230							
				± 0	± 2	± 4	± 5	± 7	± 8							
1961	7	35		146	152	167	187	211	240	270						
				± 0	± 1	± 3	± 6	± 9	±12	±16						
1960	8	34		146	152	166	186	210	239	271	303					
				± 0	± 1	± 3	± 4	± 6	±10	±13	±17					
1959	9	33		146	151	163	183	204	229	260	296	335				
				± 0	± 2	± 4	± 6	± 6	± 8	±12	±15	±18				
1958	10	18		146	151	163	178	196	216	247	281	326	372			
				± 0	± 2	± 4	± 4	± 5	± 8	±15	±21	±34	±44			
1957	11	10		146	151	163	180	204	230	264	298	355	434	487		
				± 1	± 1	± 5	±11	±17	±16	±19	±22	±36	±56	±61		
1956	12	1		148	151	162	172	189	214	247	270	350	466	608	673	
1955	13	3		147	155	168	187	205	231	254	283	327	371	434	490	547
				± 0	± 4	± 8	±16	±16	±10	±26	±55	±100	±122	±119	±117	±62
Unweighted Means				146	156	169	186	205	229	245	288	339	411	510	582	547
Mean Annual Increment				146	10	13	23	19	24	16	43	51	72	99	72	
Number of Fish				247	247	246	241	220	186	134	99	65	32	14	4	3

Table 12. Relationship between growth increments for Lake Carl Blackwell channel catfish collected in 1971 and mean annual lake level, 1962-1967, when water level was declining.

Year	Average Annual Water Level	Growth Increments in Total Length (mm) at Each Age for Year Shown							
		1	2	3	4	5	6	7	8
1967	283.9	131	9	23	14	19	13	29	41
1966	284.6	128	12	13	12	10	22	32	24
1965	285.6	128	14	9	15	11	22	18	13
1964	286.1	127	7	15	11	20	14	15	31
1963	287.0	127	4	12	15	11	8	24	1/
1962	287.6	128	6	9	7	10	16	1/	1/
Correlation coefficient (r)		-	-0.63	-0.71	-0.47	-0.40	-0.45	-0.52	-
Coefficient of determination (r^2)		-	0.40	0.50	0.11	0.16	0.20	0.27	-
Degrees freedom		-	4	4	4	4	4	3	
Probability of r		-	$P > 0.05$	$P > 0.05$	$P > 0.05$	$P > 0.05$	$P > 0.05$	$P > 0.05$	-

1/ No fish collected.

Table 13. Relationship between growth increments for Lake Carl Blackwell channel catfish and mean annual lake level, 1962-1967, when water level was declining. Growth is recalculated from data of Jerald and Brown (1970) using the derived second degree body-spine relationship.

Year	Average Annual Water Level	Growth Increments in Total Length (mm) at Each Age for Year Shown							
		1	2	3	4	5	6	7	8
1967	283.9	1/	39	28	24	26	34	30	32
1966	284.6	149	17	21	23	19	29	32	36
1965	285.6	146	9	19	18	24	29	31	34
1964	286.1	146	8	16	20	24	25	31	34
1963	287.0	146	7	15	20	21	20	34	23
1962	287.6	146	6	14	20	18	26	33	29
Correlation coefficient (r)		-	-0.84	-0.92	-0.69	-0.55	-0.81	-0.76	-0.49
Coefficient of determination (r^2)		-	0.70	0.85	0.48	0.30	0.66	0.58	0.24
Degrees freedom		-	4	4	4	4	4	4	4
Probability of r		-	$P<0.05$	$P<0.01$	$P>0.05$	$P>0.05$	$P<0.05$	$P>0.05$	$P>0.05$

1/ No fish collected.

Age	Regression
2	$Y_2 = 2186.4 - 7.6X$
3	$Y_3 = 1018.9 - 3.5X$
6	$Y_6 = 798.8 - 2.7X$

These negative correlations support the contention of Zweiacker et al. (1973) that decline in Lake Carl Blackwell's water level has increased the vulnerability of prey species by forcing them into a new littoral zone having inadequate cover. Channel catfish are known to comprise a portion of the diet of piscivorous fishes, such as largemouth bass (Zweiacker 1972) and flathead catfish (Turner 1971) in Lake Carl Blackwell. Increased predation on young channel catfish may have resulted in a reduction in intra- and interspecific competition for food. The declining water level may have also had a deleterious effect on channel catfish spawning success. Combined effects of increased predation and low year-class strength could explain the observed increase in growth. Carroll and Hall (1964) found no growth acceleration of older channel catfish following an extreme drawdown of Norris Reservoir, but growth at all ages improved in the first year-class after drawdown.

Carp

Body-Scale Relationship. Linear and curvilinear regressions for body-scale relationship were calculated from 52 carp collected by all methods in 1971. Linear and curvilinear regressions were significant ($P < 0.005$). Linear regression of total body length in mm (Y) on total scale radius in mm (X) is: $Y = 35.9 + 2.2X$ with a correlation coefficient of 0.95. Curvilinear regression is: $Y = -60.9 + 3.5X - 0.0043X^2$. Reduction of variance due to curvilinearity is significant ($P < 0.005$) and back-calculations of total length at each year of life were performed using the second-degree polynomial (Table 14). Sexes were combined in the calculation of mean length at age for each year-class because Mauck and Summerfelt (1970) found no significant differences between growth of male and female carp in Lake Carl Blackwell.

Relationship Between Carp Growth and Water Level. Correlation coefficients of growth increments in the first four years of life and mean annual lake level between the years 1962 and 1967 were calculated for both the 1971 data and those of Mauck and Summerfelt. A significant correlation was calculated for the first year of life from the 1971 data ($P < 0.01$, Table 15). The regression equation for the first year of life is: $Y_1 = -4814.7 + 17.1X$. The data of Mauck and Summerfelt provided a significant negative correlation for growth during the third year of life ($P < 0.005$, Table 16). The regression equation for the third year is: $Y_3 = 1994.0 - 6.7X$.

The observed correlations of carp growth with declining water level indicate that as the water level dropped, growth of age 1 carp decreased, while growth of age 3 carp improved. Growth of age 1 carp was probably limited by reduced littoral zone production of invertebrates while increased growth of age 3 carp may be explained in terms of a reduction in intra- or interspecific competition. A reduction in intraspecific competition could occur through a decline in reproductive success of carp. Water level drawdown during the spawning season has been demonstrated to limit reproductive success of carp (Shields 1957). Also, increased predation on carp fry and young could account for a reduction in carp numbers.

Table 14. Mean calculated total length (mm) at end of each year of life and 95% confidence limits of carp in Lake Carl Blackwell captured in 1971.

Year Class	Age Group	Number of Fish	Mean Length	1	2	3	4	5	6	7	8	9	10
1968	III	19	241	58 ±10	134 ±13	217 ±18							
1967	IV	8	353	58 ±11	153 ±15	224 ±21	317 ±33						
1966	V	10	406	65 ±18	182 ±36	259 ±27	358 ±25	386 ±22					
1965	VI	7	425	65 ±29	214 ±38	290 ±30	365 ±26	392 ±36	411 ±40				
1964	VII	5	435	90 ±32	229 ±44	329 ±67	374 ±51	401 ±55	421 ±58	432 ±61			
1963		0	-	-	-	-	-	-	-	-	-	-	-
1962	IX	1	535	121	262	315	374	411	431	447	466	480	
1961	X	1	605	65	118	175	254	310	372	475	509	550	580
Unweighted Means				75	185	258	340	380	409	451	488	515	580
Mean Annual Increment				75	110	74	75	35	30	43	26	28	30
Number of Fish				52	51	51	32	24	14	7	2	2	1

Table 15. Relationship between growth increments for Lake Carl Blackwell carp collected in 1971 and mean annual lake level, 1962-1967, when water level was declining.

Year	Average Annual Water Level	Growth Increments in Total Length (mm) for Year Shown			
		1	2	3	4
1967	283.9	58	117	76	45
1966	284.6	65	149	100	1/
1965	285.6	65	139	1/	59
1964	286.1	90	1/	57	99
1963	287.0	1/	141	57	1/
1962	287.6	121	53	1/	1/
Correlation coefficient (r)		0.94	0.52	0.73	0.83
Coefficient of determination (r^2)		0.88	0.27	0.53	0.70
Degrees freedom		4	4	2	1
Probability of r		$P < 0.01$	$P > 0.05$	$P > 0.05$	$P > 0.05$

1/ No fish collected.

Table 16. Relationship between growth increments for Lake Carl Blackwell carp and mean annual lake level, 1962-1967, when water levels were declining.[1]

Year	Average Annual Water Level	Growth Increments in Total Length (mm) for Year Shown				
		1	2	3	4	5
1967	283.9	105	90	100	76	68
1966	284.6	96	97	80	74	67
1965	285.6	128	92	81	66	74
1964	286.1	118	98	71	57	57
1963	287.0	106	92	71	77	71
1962	287.6	106	77	72	117	[2]
Correlation coefficient (r)		0.16	-0.64	-0.84	-0.26	-0.37
Coefficient of determination (r^2)		0.03	0.41	0.71	0.07	0.14
Degrees freedom		4	4	4	4	3
Probability of r		P>0.05	P>0.05	P<0.05	P>0.05	P>0.05

1/ From data of Mauck and Summerfelt (1970).

2/ No fish collected for this year.

There is a possibility that Lee's phenomenon produced the negative correlations observed for growth of carp with water level. However, there is an absence of known fishing pressure on this species that might cause selective mortality; and, the combination of collection methods used in sampling tends to rule out sampling bias as a cause. Moreover, lowering water levels would likely cause selection for larger fish due to increased predation on smaller, slow growing individuals.

CHAPTER VI

RELATIVE ABUNDANCE

Introduction

The water level fluctuations of Lake Carl Blackwell are believed to have exerted stresses upon the fish community related to predator-prey relationships, population density, and food production which would have altered levels of competition and changed species dominance.

The seven year decline in water level of Lake Carl Blackwell ended in early 1967. After reaching 282.7 m, msl, the water level rose 0.6 m to 283.4 m, msl by mid-June, 1967 (Figure 1). In the summer of 1967, the Oklahoma Cooperative Fishery Unit conducted gill net and electro-fishing collections to determine horizontal distribution of fishes (Summerfelt 1971). The objective of this portion of the study is to compare the gill net and electro-fishing catch in 1967 with collections made in 1971 to detect changes in relative abundance that have occurred in the fish community. Interpretation of changes in catch between sampling periods, as related to water levels, is complicated by periodic water level fluctuations that occurred between years. However, the analysis may provide insight into the response of certain components of the fish community to a general decrease in water level.

The period between 1967 and 1971 was characterized by vernal and fall fluctuations with an especially severe decline in 1970 which reached a record low in the fall of 1971. Mean water level during the

1971 sampling period reduced the level to 83 percent and the volume to 88 percent of the values recorded in 1967.

Materials and Methods

Catch is proportional to fish abundance if sampling effort or fish distribution is random. Because of vagaries in fish behavior and environmental factors, these conditions are seldom attained. However, catch per unit effort is related to fish abundance when relative fishing effort directed toward different portions of a population and factors influencing catch of any fish species are constant with time (Ricker 1958).

When evaluating catches on a comparative basis, gear selectivity can be disregarded but movement and associative patterns for a species must be assumed similar each year under similar sampling conditions.

Gill Nets

Four major habitat areas [(Transects 1, 3, 5, and 7 (Figure 2)] had been sampled with experimental gill nets in 1967 (Summerfelt 1971). Six random net sets were made along each transect in June and again in August. Three sets were made in the old stream channel and three sets were made on the flood plain. To compare catch per unit effort between years, nets were set in 1971 to duplicate the 1967 effort. Those sets made on the flood plain were duplicated as nearly as possible with respect to time, location, and gear type. There was not time to sample both channel and flood plain habitats; therefore, channel sets were eliminated because the catch rate in 1967 was significantly higher in the flood plain than the channel (Summerfelt 1971). Five additional sets were made in July, 1971, to increase sample size.

Design of gill nets used during both sampling periods was essentially identical. Fish were captured during both the 1967 and 1971 sampling periods with 45.7 m experimental gill nets containing three 15.2 m sections each of 25 mm, 51 mm, and 76 mm square mesh. The nets were 2.4 m deep hobbled to 1.8 m. All nets were anchored to the bottom and set at right angles to the shoreline for approximately 24 hours. Fish were removed after 12 hours and again at the end of 24 hours when the net was removed from the water. All fish were weighed and measured in the field. Weight was recorded to the nearest ounce on fish heavier than one pound and to the nearest gram on smaller fish. Total length was recorded to the nearest millimeter.

Moyle (1949) and Moyle and Lound (1960) have shown that catch in numbers of fish of a series of gill nets have the following attributes: (1) a standard deviation that is usually about the size of the mean; and (2) a distribution curve of the catches that is usually positively skewed, indicating more catches below the mean of the series than above it. Standard statistical procedures can be applied to mean catch for each transect, however, since the frequency distribution of the mean in repeated samples drawn from a skewed distribution tends to become normal as sample size is increased (Snedecor and Cochran 1967).

Analysis of variance was conducted on net catch using four criteria: (1) total catch in numbers for each transect; (2) total catch in weight for each transect; (3) catch for each year, 1967 and 1971; (4) catch for each month June, July, and August. Day and night catches were combined and considered as one (24-hour) unit of effort. Flathead catfish, white bass, bluegill, and longear sunfish were excluded from the analysis because of their infrequent appearance in the catch. When significant ($P < 0.05$) F values were obtained, a t-test with pooled variance was used to determine the significance of difference between the two years for each transect (Snedecor and Cochran 1967).

Electro-fishing

Shoreline electro-fishing had also been conducted in 1967 along 137 m sections on the north and south ends of Transects 1, 3, 5, and 7. Day and night sampling runs were conducted on each transect, three times in June and three times in August, 1967. Each of these sampling efforts was duplicated as nearly as possible in 1971 with respect to time and location. Additional sampling was conducted in July to increase sample size. In all, each transect was sampled twice each week throughout the summer of 1971. One sampling run was made during the day and one run during the night. Electro-fishing was conducted from a 4.8 m aluminum flat-bottom, boom-type shocker boat. Current was provided by a 180 cycle, 230-volt, 3,000 watt AC generator. The electro-fishing crew consisted of a boat operator and a man positioned on the bow to collect fish with a long-handled dip net. Though there is no quantitative method for comparing the efficiency of operators, it is assumed that sampling efficiency between years was comparable.

Analysis of variance was conducted on the electro-fishing data using the following criteria: (1) total catch in numbers and weight per section, (2) total catch in numbers and weight per transect, (3) total catch in numbers and weight per month, and (4) analyses of 1-3 by species. Results from each day and corresponding night sampling effort were combined and considered as one unit of effort. Both the 1967 and 1971 data were treated in this manner. Bluegill, longear, redear, green and orangespot sunfish, as well as white bass were excluded from analyses due to their infrequent appearance in the catch. Only electrofishing runs having a corresponding day or night effort occurring within a 24-hour period were used in the analysis of variance.

Results and Discussion

Comparison of Gill Net Catch Per Unit Effort Between Years

Major changes in total catch per unit effort over all transects occurred only with river carpsucker and channel catfish. Catch per unit effort in both numbers ($\bar{C}_n$) and weight ($\bar{C}_w$) of river carpsucker decreased significantly ($P < 0.01$) over all transects between 1967 and 1971 (Tables 17 and 18). Total $\bar{C}_n$ for 1967 was 6.07 compared to 3.88 for 1971. Total $\bar{C}_w$ for 1967 and 1971 was 5282.7 g and 2696.0 g, respectively. The decrease was significant between years on Transects 5 ($P < 0.005$) and 7 ($P < 0.05$).

Total $\bar{C}_n$ for channel catfish decreased over all transects from 5.23 fish in 1967 to 2.26 in 1971 ($P < 0.05$). Total $\bar{C}_w$ decreased significantly ($P < 0.05$) from 973.8 g in 1967 to 441.7 g in 1971. Only Transect 3 showed a significant ($P < 0.05$) difference in catch where $\bar{C}_n$ decreased from 9.83 (1967) to 2.54 (1971).

Although no other differences in total $\bar{C}_n$ or $\bar{C}_w$ over all transects were significant between years, some changes did occur by transects between years. White crappie $\bar{C}_n$ more than doubled at Transect 3 from

Table 17. Average fish catch per unit effort ($\bar{C}_w$) in weight (g) by sampling gear in Lake Carl Blackwell, 1967 and 1971, all transects combined (number of fish in parenthesis).

	June through August 1967			June through August 1971		
Species	Gill Nets	Electro-shocker	Total Weight of Fish	Gill Nets	Electro-shocker	Total Weight of Fish
Carp	1502.1 (64)	773.0 (54)	2275.1	1862.8 (124)	194.2[1/] (43)	2057.0
River Carpsucker	5282.7 (158)	916.6 (82)	6199.3	2696.0[1/] (175)	961.6 (84)	3657.6
Channel Catfish	973.8 (136)	83.2 (16)	1057.0	441.7[2/] (102)	142.3 (77)	584.0
Flathead Catfish	-	108.7 (9)	108.7	-	21.1 (6)	21.1
White Crappie	685.6 (293)	34.0 (10)	719.6	938.3[2/] (650)	15.6 (9)	953.9
Gizzard Shad	247.7 (126)	1920.2 (2430)	2167.9	291.8 (169)	1012.7[1/] (851)	1304.5
Freshwater Drum	300.1 (88)	134.2 (153)	434.3	365.7 (190)	127.9 (229)	493.6
Largemouth Bass	None	827.8 (55)	827.8	None	108.5[1/] (16)	108.5
Fishing Effort	26 Days	48 Runs	-	45 Days	56 Runs	-
Total Weight of Fish	8992.0	4797.7	13789.7	6596.3	2583.9	9180.2

[1/] Significant difference between years ($P < 0.01$). [2/] Significant difference between years ($P < 0.05$).

Table 18. Average fish catch per unit effort in numbers ($\overline{C}_n$) by sampling gear from combined transects in Lake Carl Blackwell, 1967 and 1971 (number of fish in parenthesis).

Species	June through August 1967			June through August 1971		
	Gill Nets	Electro-shocker	Total Number of Fish	Gill Nets	Electro-shocker	Total Number of Fish
Carp	2.46 (64)	1.13 (54)	118	2.77 (124)	0.77 (43)	167
River Carpsucker	6.07 (158)	1.71 (82)	240	3.88[2] (175)	1.50 (84)	259
Channel Catfish	5.23 (136)	0.33 (16)	152	2.26 (102)	1.37 (77)	179
Flathead Catfish	-[3]	0.18 (9)	9	-[3]	0.11 (6)	6
White Crappie	11.27 (293)	0.21 (10)	303	14.44 (650)	0.16 (9)	659
Gizzard Shad	4.85 (126)	50.62 (2430)	2556	3.76 (169)	15.20[1] (851)	1020
Freshwater Drum	3.38 (88)	3.45 (166)	254	4.22 (190)	4.09 (229)	419
Largemouth Bass	0.0	1.14 (55)	55	0.0	0.28[1] (16)	16
Fishing Effort	26 Days	48 Runs	-	45 Days	56 Runs	-
Total Number of Fish	865	2822	3687	1473	1315	2946

[1] Significant difference between years ($P < 0.001$).

[2] Significant difference between years ($P < 0.05$).

[3] Not included in analysis.

10.83 in 1967 to 22.54 in 1971 ($P < 0.05$). White crappie $\overline{C}_w$ at Transect 3 also increased greatly from 506.6 g to 1402.8 g ($P < 0.05$).

Catch ($\overline{C}_n$) of gizzard shad decreased from 10.71 to 4.33 at Transect 1 ($P < 0.05$).

Freshwater drum $\overline{C}_n$ increased significantly ($P < 0.05$) at Transect 7 from 3.28 to 7.44 as did the $\overline{C}_w$ from 187.9 g to 604.1 g.

The decrease in the catch per unit effort of channel catfish supports the earlier hypothesis that the water level drawdown has affected spawning success and/or competition. Although the period studied for growth analysis ends in 1967, factors influencing growth would continue in 1971, and therefore suggests a trend that continued to 1971. The decrease in abundance of river carpsucker presumably resulted from decreased spawning success.

Comparison of Electro-fishing Catch Per Unit Effort Between Years

Analysis of variance of the total catch per unit effort in numbers shows that two significant ($P < 0.01$) changes had occurred (Tables 17 and 18). Catch of gizzard shad had decreased from 50.6 (1967) to 15.2 fish per unit effort (1971). Catch of largemouth bass also decreased from 1.1 fish in 1967 to 0.3 fish in 1971. No other changes in numerical abundance were significant (Table 18).

The catch in weight ($\overline{C}_w$) of gizzard shad and largemouth bass also decreased significantly ($P < 0.01$) since 1967. Gizzard Shad declined from 1920.2 g in 1967 to 1012.7 g in 1971 and largemouth bass declined from 827.8 g to 108.5 g.

Lake Carl Blackwell water level fluctuations have probably affected year-class strength of largemouth bass as evidenced by decreases in total $\overline{C}_n$ and $\overline{C}_w$. Zweiacker (1972) estimated that the largemouth bass population had declined from 1,771 in June-July, 1968 to 1,388 in August-September, 1969.

Utility of catch per unit effort indices is limited when environmental variables are suspected to influence conditions of capture. One of the assumptions underlying catch per unit effort analyses is that factors influencing catch of any fish species are constant with time. Acceptance of this assumption is questionable since the nature of the littoral areas had changed extensively between the sampling periods. These changes may have influenced spatial distribution of fishes sufficiently to affect the catch by gear, such as an electroshocker, that is restricted to one habitat type (e.g., littoral). Also, reduction in lake water volume would have a strong influence on catch. Assuming population numbers to be static, reduction in lake volume would increase the probability of contact with fishing gear, and result in an increase in catch per unit effort. Such an increase could give a false indication of an increase in abundance of fishes. Conversely, any decrease in catch per unit effort occurring in spite of this "crowding phenomenon" would strengthen an interpretation of a real decrease in abundance. Considering this, decreases noted in the 1971 gill net catch are probably strong indicators of real population changes, especially since these data are supported by concurrent findings in the gill net and electroshocker catch, as is the case with gizzard shad.

Gill net per unit effort indices have been used by other investigators to relate water level to fish abundance. Hervey (1963) found a significant correlation between relative year-class strength and mean annual lake levels of Clear Lake, Iowa based on gill net catches.

CHAPTER VII

STANDING CROP

Introduction

Rotenone samples of fish populations are widely used and generally accepted as a quantitative measure of reservoir fish standing crop (Lambou and Stern 1958, Carter 1958, Chanch 1958, Hayne et al. 1967). Fish standing crop estimates were obtained in Lake Carl Blackwell (1966 through 1969 and 1971) by cove rotenone samples using a block net to delimit sampling area. Standing crop data from these years is examined in relation to fluctuations in water level.

Materials and Methods

An estimate of standing crop was made from four cove rotenone samples taken in July, August, and September 1971. Three of these samples were taken in one cove near the dam where all previous rotenone collections had been made (Figure 2, Cove A). The use of this cove reduces the variables affecting the estimate when making comparisons with previous standing crop estimates.

Cove A is situated in the easternmost arm on the north side of the lake. The cove is on the west side of the arm and is surrounded by steep-sided rock bluffs and trees which protect it from prevailing winds. Turbidity in this cove appears to be lower than it is in the rest of the lake. At 1971 summer water levels, Cove A was, at maximum, about 4 to 5 m deep and about 15 m wide.

Cove A is deeper and calmer than most other coves on the lake. Consequently, standing crop estimates from this cove may not be representative of populations in the entire lake. Therefore, in 1971, another rotenone sample was taken from a shallow cove (Cove B) in the middle portion of the lake to provide a comparison of the standing crop estimates made from Cove A. Maximum depth of Cove B at time of sampling was 1.7 m with an average depth of about 0.9 m. This cove is wind swept and generally turbid. The shoreline is composed of sand and mud and slopes gradually from rolling pasture fields.

Prior to sampling, the area of each cove was estimated by a field survey utilizing a plane-table and triangulation techniques. Depth soundings were made along a series of transects to establish bottom contours. The resulting area and depth measurements were used to calculate total water volumes of the coves. These volumes were used in estimating the quantity of five percent rotenone required to produce a total concentration of 1.5-2.0 ppm (0.075-0.1 ppm active rotenone). This concentration was chosen to ensure a complete kill. Additional field measurements were made in late summer to account for volume changes with decreased water level.

A block net (Lambou 1959) was set across the mouth of the coves on the morning of the first day's ampling. A screen of rotenone was first applied behind the block net to direct fish away from the net. Rotenone was applied shortly afterward through a venturi nozzle attached behind the prop of an outboard motor, and a light application was made initially to ensure a more complete pick up of fish by field personnel.

Subsequent application was made by driving the boat around the cove and distributing the rotenone in the propwash. Because the cove was relatively shallow, the vigorous disturbance of the water by the outboard propwash was believed to cause complete vertical mixing of the rotenone. Mark and recapture methods to estimate percent recovery were not utilized in this sampling as previous standing crop estimates were made without the aid of such techniques.

All fish recovered were separated by species, then weighed and measured. When large numbers of small fish were encountered, total length was measured by inch-class as suggested by Surber (1960).

The block net was left in position for 72 hours to ensure adequate time for maximum recovery of fish. Following the first day's collection, the cove was checked once in the morning and once in the late afternoon for any additional fish that had surfaced. Henley (1967) found that 74 percent of the number and 95 percent of the weight of all fish are recovered on the surface within 52 hours.

Results and Discussion

Standing Crop Estimates

Summaries of rotenone collection data taken by personnel of the Oklahoma Cooperative Fishery Unit in 1966, 1967, and 1968 are presented in Table 19. These data show a great deal of seasonal variability in total standing crop of fish, a common characteristic of cove sampling (Hayne et al. 1967). Total standing crop from the 1966-1968 samples ranged from 26.9 kg/ha in March, 1967, to 352.9 kg/ha in May, 1968. Standing crop estimates from July and October, 1967 were chosen for

Table 19. Standing crop of fishes (kg/ha) by species collected in Cove A, Lake Carl Blackwell, Oklahoma.

Species	6 Dec 66	3 Mar 67	23 May 67	17 Jul 67	23 Oct 67	May 68
Carp	5.1	12.7	38.5	1.4	48.9	3.5
River Carpsucker	-	-	-	0.9	<0.1	4.1
Channel Catfish	5.9	2.2	9.3	6.5	2.3	8.7
Flathead Catfish	-	-	0.9	0.2	-	3.0
White Crappie	6.5	1.1	69.2	5.6	15.8	1.7
Gizzard Shad	1.0	0.6	113.6	116.7	35.1	68.6
Largemouth Bass	12.5	4.9	93.1	7.7	9.0	3.2
Drum	-	-	4.8	5.4	24.4	12.2
White Bass	0.1	-	0.6	2.7	-	1.9
Bluegill	5.1	4.3	18.6	2.9	4.5	5.4
Green Sunfish	3.1	0.1	0.7	0.7	1.7	1.4
Orangespot Sunfish	0.2	0.2	1.1	1.2	1.1	0.6
Longear Sunfish	2.0	0.8	2.5	2.9	3.2	0.9
Northern Pike	-	-	-	-	-	0.1
Totals	41.5	26.9	352.9	154.8	146.1	115.3

comparison with the 1971 estimate in order to eliminate seasonal variability. The mean of these two 1967 samples is 150.4 kg/ha.

The 30 July collection yielded a total of 64.4 kg of fish, or the equivalent of 146.0 kg/ha (Table 20). The 11 August collection yielded 186.7 kg/ha while the 25 August collection yielded 170.9 kg/ha (Tables 20 and 21). The equivalent of 114.8 kg/ha was collected from Cove B on 11 August. The mean standing crop from all four samples was 154.3 kg/ha (Table 22).

Standing crop in Lake Carl Blackwell of 154.3 kg/ha is low in relation to mean standing crop of 337.2 kg/ha from 16 Oklahoma reservoirs reported by Jenkins (1967). A mean of 211.3 kg/ha was reported by Jenkins for 127 U.S. reservoirs. The Lake Carl Blackwell standing crop was also less than the mean of 192.3 kg/ha from other reservoirs having nutrient input consisting primarily of K^+, Na^+, SO_4^-, Cl^- (Jenkins 1967).

Comparison of Standing Crop Estimates

Between Years

Standing crop estimates for Cove A derived from collections made 17 July, 1967 and 30 July, 1971 (Tables 19 and 20) were chosen for comparison since only this comparison was thought to be relatively free of seasonal differences.

The variance for the test of difference between the 1967 and 1971 samples was estimated from the 30 July and 11 August, 1971 samples (Table 20). The standard deviation of 28.8 from this calculation compared very favorably with the standard deviation of 52.6 reported by Hayne et al. (1967) which they derived from a sample of nine "minor" coves (ranging in size from 0.52 to 3.25 ha). The mean total biomass

Table 20. Numbers and weights of fishes collected in two cove rotenone surveys of Cove A, Lake Carl Blackwell, Oklahoma (exclusive of minnows).

	30 July, 1971					11 August, 1971				
Species	No.	%	Wt.(g)	%	kg/ha	No.	%	Wt.(g)	%	kg/ha
Carp	66	4.2	13,448	20.9	30.5	71	7.4	23,293	28.4	52.8
River Carpsucker	27	1.7	8,762	13.6	19.9	49	5.1	20,040	24.5	46.3
Channel Catfish	4	0.2	699	1.1	1.6	12	1.2	778	0.9	1.8
Flathead Catfish	8	0.5	496	0.7	1.1	-	-	-	-	-
White Crappie	61	3.8	2,179	3.4	4.9	79	8.2	2,854	3.5	6.5
Gizzard Shad	499	31.3	28,026	43.5	63.5	479	50.2	19,159	23.4	43.5
(Young-of-year)	502	31.5	1,500	2.3	3.4	-	-	8,137	9.9	18.5
Largemouth Bass	10	0.6	2,766	4.3	6.3	8	0.8	1,787	2.2	4.0
Drum	109	6.8	2,374	3.7	5.4	131	13.7	2,755	3.4	6.2
White Bass	3	0.2	10	<0.1	<0.1	19	2.0	809	1.0	1.8
Bluegill	141	8.8	1,655	2.5	3.8	53	5.6	800	1.0	1.8
Green Sunfish	102	6.4	1,427	2.2	3.2	7	0.7	248	0.3	0.6
Orangespot Sunfish	30	1.9	143	0.2	0.3	15	1.6	116	0.1	0.3
Longear Sunfish	30	1.9	897	1.4	2.0	30	3.1	1,134	1.4	2.6
Total	1,592		64,388		146.0	953		81,910		186.7

Table 21. Numbers and weights of fishes collected in cove rotenone surveys of Cove A (25 August, 1971) and Cove B (13 September, 1971), Lake Carl Blackwell, Oklahoma.

	25 August, 1971					13 September, 1971				
Species	No.	%	Wt.(g)	%	kg/ha	No.	%	Wt. (g)	%	kg/ha
Carp	89	10.1	21,802	29.0	49.5	51	1.2	11,762	13.4	15.2
River Carpsucker	51	6.0	20,597	27.4	46.8	4	<0.1	4,696	5.3	6.1
Channel Catfish	9	1.1	738	1.0	1.7	137	3.2	4,183	4.7	5.4
White Crappie	22	2.6	735	1.0	1.7	45	1.0	1,866	2.2	2.4
Gizzard Shad	504	59.4	8,576	11.4	19.5	816	19.0	25,546	29.1	33.2
(Young-of-year)	-	-	17,618	23.4	40.0	2,182	50.9	19,867	22.6	25.8
Largemouth Bass	8	0.9	1,670	2.2	3.8	6	0.1	1,188	1.3	2.4
Drum	116	13.7	2,533	3.4	5.8	348	8.1	14,458	16.5	18.8
(Young-of-year)	-	-	-	-	-	630	14.7	3,330	3.8	4.3
White Bass	11	1.3	382	0.5	0.9	34	0.8	536	0.6	0.7
Bluegill	37	4.4	523	0.7	1.2	10	0.2	177	0.2	0.2
Green Sunfish	1	0.1	37	<0.1	<0.1	-	-	-	-	-
Orangespot Sunfish	2	0.2	16	<0.1	<0.1	16	0.3	109	0.1	0.1
Longear Sunfish	1	0.1	32	<0.1	<0.1	9	0.2	138	0.2	0.2
Totals	848		75,259		170.9	4,288		87,796		114.8

Table 22. Standing crop (kg/ha) of fishes by species from Lake Carl Blackwell, 1971.

Species	Cove A		Cove B		Mean	%	C.V.[1/]
	7/30/71 (1)	8/11/71 (2)	8/25/67 (3)	9/13/67 (4)			
Carp	30.5	52.8	49.5	15.2	37.0	24.0	0.27
River Carpsucker	19.9	46.3	46.8	6.1	29.8	19.3	0.41
Channel Catfish	1.6	1.8	1.7	5.4	2.6	1.7	0.05
Flathead Catfish	1.1	-	-	-	0.3	0.2	-
White Crappie	4.9	6.5	1.7	2.4	3.9	2.5	0.56
Gizzard Shad	66.9	62.0	59.5	59.0	61.8	40.0	0.04
Largemouth Bass	6.3	4.0	3.8	2.4	4.1	2.6	0.30
Drum	5.4	6.2	5.8	23.1	10.1	6.5	0.07
White Bass	<0.1	1.8	0.9	0.7	0.8	0.5	0.91
Bluegill Sunfish	3.8	1.8	1.2	0.2	1.7	1.1	0.60
Green Sunfish	3.2	0.6	<0.1	-	0.9	0.6	1.28
Orangespot Sunfish	0.3	0.3	<0.1	0.1	0.2	0.1	0.50
Longear Sunfish	1.4	2.6	<0.1	0.2	1.1	0.7	0.92
Totals	146.0	186.7	170.9	114.8	154.3		
kg/ha	128.5	164.3	150.4	101.0	135.8		

[1/] Coefficient of variability (S.D./mean) for Samples 1-3, Cove A.

of 166.35 kg/ha that was recorded for the Lake Carl Blackwell (Cove A) was essentially the same as the mean of 167.3 kg/ha reported by Hayne et al. (1967) indicating that the problem they noted of the variance apparently being a function of the mean value was negligible in this case.

To declare a statistically significant difference between the total biomass (B) values for 1967 and 1971, the following relationship must occur:

$$B_{67} - B_{71} > t_{.05} \sqrt{2S^2}\ ,\ \text{d.f.} = 1$$

where S^2 is the variance derived from the 1971 samples.

Substituting the observed values we have:

$$184.7 - 146.0 > 12.706 \sqrt{2(828.2)} \quad \text{and} \quad 8.8 \not> 517.1.$$

We may conclude that the observed difference in total biomass between 1967 and 1971 of 8.8 kg/ha is due to a random variable and not to the lower water level.

As a further check of difference, a paired t-test was run since the same species were observed both sample years. A t of 0.1385 (d.f. = 12, $P > 0.5$) was computed for the mean difference/species of 0.68 kg/ha, thus corroborating the original conclusion that there is no significant difference between the total fish biomass observed in 1967 and 1971.

CHAPTER VIII

SUMMARY

Data representing fishes collected from Lake Carl Blackwell from June, 1966 to September, 1971 were analyzed to ascertain changes in species composition and to correlate growth, relative abundance, and standing crop of fishes with decreasing water levels associated with chronic drought conditions.

At spillway level, Lake Carl Blackwell has a surface area of 1,214.2 ha and a volume of 68 million cubic meters. A record low of 282.9 m, msl (4.9 m below spillway level) was reached 17 September, 1971 which reduced surface area to 667 ha, 60 percent of the area at spillway level. Total volume was reduced to 1.9 X 10^7 m^3, 29 percent of maximum volume at spillway.

In 1971, the lake lacked gar (*Lepisosteus* spp.) and buffalo fishes (*Ictiobus* spp.), two genera common to many other Oklahoma reservoirs. Twenty species were collected by all methods throughout the study period. Gizzard shad and white crappie were the two numerically predominant species. Black crappie have disappeared from the lake in recent years, probably due to the high turbidity. The most abundant minnow was the red shiner, *Notropis lutrensis*. The second most abundant minnow collected was the bullhead minnow, *Pimephales vigilax*. The plains minnow, *Hybognathus placitus*, once common in the lake, has apparently been replaced by the introduced *P. vigilax*. Earlier stockings of walleye (*Stizostedion vitreum vitreum*) and northern pike (*Esox lucius*) were apparently unsuccessful as there was no evidence of reproduction.

Variations in annual increments of growth of white crappie, channel catfish, and carp were examined in relation to mean annual water level of Lake Carl Blackwell, 1962-1967, when lake level was declining. The occurrence of Lee's phenomenon precluded a correlative comparison of white crappie growth with water level, but the decrease in growth at age 1 and the increase at older ages during the 1960's is attributed to the decline in water level. The crappie body-scale relationship changed from curvilinear to linear as growth improved during the drawdown period. Channel catfish growth was compared to mean annual water levels and correlations were significant for age 1 ($r = -0.84$, $P < 0.05$), age 2 ($r = -0.92$, $P < 0.01$) and age 6 ($r = -0.81$, $P < 0.05$). Correlations of carp growth with mean annual water levels were significant for age 1 ($r = 0.94$, $P < 0.01$, Table 15) and age 3 ($r = -0.84$, $P < 0.05$, Table 16).

Declining water level was believed to have adversely affected the growth of age 1 carp by reducing littoral zone production and positively affected the growth of older carp and channel catfish through reduced intra- and interspecific competition. The reduction in competition is believed to result from decreased spawning success and increased predation upon small carp and channel catfish by piscivorous fishes such as largemouth bass and flathead catfish.

Changes in relative abundance and catch per unit effort of gill net and electroshocker catch since 1967 were examined. Catch per unit effort of river carpsucker and channel catfish by gill nets decreased significantly ($P < 0.01$) over all transects between 1967 and 1971. This decline in abundance is believed to be largely due to decreased spawning success with fluctuating water levels. Electro-fishing catch per unit effort in number and weight of gizzard shad and largemouth bass decreased significantly ($P < 0.01$) between 1967 and 1971. Decrease in largemouth bass catch is believed to have resulted from reduced spawning success related to fluctuating water levels between 1967 and 1971.

Estimates of standing crop of fishes were made from cove rotenone surveys in 1966-1969, and 1971. The mean standing crop of the four 1971 cove rotenone collections was 154.3 kg/ha. The mean from comparable estimates in 1967 was 150.4 kg/ha. There was no statistical difference between these two means.

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VITA

Jeffrey Nelson Johnson

Candidate for the Degree of

Master of Science

Thesis: EFFECTS OF WATER LEVEL FLUCTUATIONS ON GROWTH, RELATIVE ABUNDANCE AND STANDING CROP OF FISHES IN LAKE CARL BLACKWELL, OKLAHOMA

Major Field: Zoology

Biographical:

Personal Data: Born in Tulsa, Oklahoma, January 20, 1943, the son of Paul Herrick and Maida Lucille Johnson.

Education: Graduated from Thomas A Edison High School, Tulsa, Oklahoma, 1961; received the Bachelor of Science degree with a Biology major from Central State University, Edmond, Oklahoma in May, 1967; completed the requirements for the Master of Science degree in May, 1974 at Oklahoma State University, Stillwater, Oklahoma.

Professional Experience: Graduate Research Assistant, Oklahoma Cooperative Fishery Unit, November, 1970-December, 1972; Biologist's Aide, Oklahoma Department of Wildlife Conservation, May, 1970-September, 1970; Assistant Aquatic Ecologist, Dames and Moore, Cincinnati, Ohio, January, 1973-May, 1974.

Member: American Fisheries Society; Ecological Society of America, Phi Kappa Phi Honor Society.