SURVIVAL OF STOCKED CHANNEL CATFISH
IN SMALL PONDS

By

GERALD EUGENE MESTL

Bachelor of Arts

Mount Marty College

Yankton, South Dakota

1980

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
MASTER OF SCIENCE
May, 1983

SURVIVAL OF STOCKED CHANNEL CATFISH

IN SMALL PONDS

Thesis Approved:

O. Eugene Maughan
Thesis Adviser

Michael D. Clady

Anthony A. Echelle

R. W. Bill Altman

Norman N. Durham
Dean of Graduate College

PREFACE

This research was conducted in cooperation with the Fort Sill Fish and Wildlife Branch. The research was conducted on Fort Sill Military Reservation near Lawton, Comanche County in southwest Oklahoma. Our objective was to study survival of stocked channel catfish fry and fingerlings in small ponds and to make management recommendations.

I would like to thank my parents, Eugene and Lavina, family, and friends for the support and encouragement they gave me during my college career. I thank Dr. Eugene Maughan and Dr. Michael Clady for the opportunity to do this research, assistance with the project, and review of thesis drafts. I thank Dr. Anthony Echelle and Dr. Ralph Altman for serving on my committee. Special thanks are due Gene Stout, Lloyd Payne, Larry Adams, and all who assisted me while I was at Fort Sill.

Final thanks go to the students and technicians of the Oklahoma Cooperative Fishery Research Unit who assisted with this project whether through field work, critical input or moral support.

TABLE OF CONTENTS

Chapter		Page
I.	INTRODUCTION	1
II.	OBJECTIVES	5
III.	RESEARCH AREA	6
IV.	PHASE ONE-PRELIMINARY STUDY	7
	Materials and Methods	7
	Results	8
	Discussion	14
V.	PHASE TWO-FRY SURVIVAL STUDY	15
	Materials and Methods	15
	Results	18
	Discussion	20
VI.	PHASE THREE-FINGERLING SURVIVAL STUDY	25
	Materials and Methods	25
	Results	31
	Discussion	51
VII.	MANAGEMENT RECOMMENDATIONS FOR FORT SILL PONDS	55
LITERATURE CITED		56
APPENDIX		59

LIST OF TABLES

Table — Page

I. Area (hectares), number of channel catfish stocked since 1977, and number recpatured in 1980 in the five study ponds 9

II. Lengths (mm), weights (g), and condition factors (K) of channel catfish captured during 1980 9

III. Dissolved oxygen concentrations (mg/l) for all ponds for July and August, 1980 12

IV. Secchi disk readings (centimeters) for all ponds for July and August, 1980 12

V. Water temperature (°C) of study ponds at selected depths for July and August, 1980 13

VI. Type of channel catfish fry stocked, type of pond stocked (V-virgin pond, I-introduced and E-existing predator populations), date stocked, number of fry stocked, number recaptured, mean weight (W) (grams) of fry at stocking, mean weight at rotenoning, mean daily growth (grams/day), and mean condition (K) for ponds on Fort Sill 19

VII. Pond area, time in days between stocking and harvest, length stocked, number stocked, number recovered, and percent survival of catfish in 11 ponds on Fort Sill . . . 40

VIII. Projected survival of catfish in 11 ponds on Fort Sill . . . 42

IX. Date of stocking , number of fish stocked, number recaptured, mean weight (grams) at stocking, mean weight at recapture, mean daily growth (grams/day), and mean condition (K) of channel catfish fingerlings mm) stocked in ponds on Fort Sill 44

X. Days between stocking and harvest, percent survival, average total length at stocking (mm), average total weight at stocking (grams), average total length at harvest, and average total weight at harvest of channel catfish in 11 ponds on Fort Sill 45

Table		Page

XI. Number of largemouth bass marked and recovered for each pond, percent recovery of largemouth bass, number of sunfish marked and recovered, and percent recovery of sunfish in 1982 46

XII. Recovery of largemouth bass from 12 ponds on Fort Sill . . . 47

XXI. Predation of largemouth bass on channel catfish 49

XIV. Physical parameters of 14 ponds on Fort Sill 50

LIST OF FIGURES

Figure Page

1. Length-frequency distribution of channel catfish (< 340 mm) from Engineer Pond in 1980 11

2. Average growth of channel catfish in Engineer Pond, five Oklahoma ponds, and the state average 11

3. Length-frequency distribution for largemouth bass stocked in ponds on Fort Sill in 1982 19

4. Number of sunfish > 200 mm actually recovered and estimated number per hectare for the three ponds stocked with fry in 1982 22

5. (A-C) Status of populations of potential predators and potential prey, theoretical predator size, and numbers in 12 ponds on Fort Sill Military Reservation
   A. East Gypsy B. West Gypsy and C. Weed 24

6. Relationship of total length of channel catfish and bluegill (theoretical prey) to total length of largemouth bass (theoretical predators) 30

7. (A & B) Predator populations in two ponds on Fort Sill Military Reservation
   A. Lower Strange and B. Mesquite 33

8. (D-L) Status of populations of potential predators and potential prey, theoretical predator size, and numbers in 12 ponds on Fort Sill Military Reservation
   D. Quawpa E. Ouray and F. Indian 35
   G. Airfield H. Mesquite and I. Lower Strange 37
   J. Winnebago K. Lower Rabbit and L. Caddo 39

CHAPTER I

INTRODUCTION

The channel catfish, Ictalurus punctatus is a popular sport fish in Oklahoma. In fact, a survey of Oklahoma fishermen showed that the channel catfish was the second most preferred and the third most sought after sportfish in the state (Mense 1978). With such high demand, natural reproduction often fails to maintain acceptable fish numbers. To supplement natural reproduction or initate a population, managers sometimes stock hatchery raised fingerlings.

In lakes (herein defined as lentic bodies of water greater than two hectares, surface area), a single stocking often results in a self-sustaining population. However, supplemental stocking of fry or fingerlings is sometimes required to offset poor reproductive years and/or compensate for very high fish mortality (fishing or natural).

In ponds (herein defined as lentic bodies of water less than two hectares, surface area) a single stocking may lead to establishment of catfish populations. However, supplemental stocking or introduction of fry or fingerlings into ponds containing established fish populations are not generally successful. Therefore, advanced fingerlings or yearlings are often stocked in such waters. The fisheries manager is faced with two conflicting demands. Increasing costs of stocking channel catfish fingerlings make it desirable to maximize survival by stocking larger. However increasing rearing costs makes the stocking of smaller fish more desirable. Given the increasing demand for channel catfish fisheries and these conflicts, a manager needs to understand the dynamics between stocked fish and their surroundings.

To obtain maximal survival at minimal cost, managers strive to develop a stocking formula which relates mortality of stocked fish to pond surface area, depth, turbidity, vegetative cover, known predator populations, available prey for predators, and size at stocking. Previous work on catfish mortality has emphasized the relationship between survival and single factors in the environment. The goal of my experiment was to simultaneously evaluate several factors affecting channel catfish survival.

A preliminary survey on the Fort Sill Military Reservation showed that channel catfish numbers were low in 80% of the ponds sampled, and there was no evidence of successful natural reproduction. Because many ponds on Fort Sill are stocked annually, the absence of catfish was unexpected and represented a considerable loss of resources. Thus I was asked to investigate the causes of low survival of channel catfish fingerlings and fry and to make management recommendations for size of channel catfish to be stocked. The study was broken down into an evaluation of the survival of two types of channel catfish fry plus the survival of various sized fingerlings. Drought conditions in 1980 had eliminated fish from some ponds, while others retained fish populations. High rainfall in 1981 refilled ponds. The result of the drought and subsequent high rainfall was ponds with existing fish populations plus those devoid of fish life (virgin ponds). These virgin ponds allowed survival of stocked channel catfish to be studied in the absence of other species or alternatively to study survival where we had constructed the population structure of the bass and sunfish by introduction.

Managers believe that size at stocking plus the number of predators present are the most important factors affecting catfish survival. McGinty (1980) found 74-98% survival of channel catfish "fry" stocked into ponds with no predators and Elrod (1971) found much better catfish survival when small channel catfish and bass were stocked simultaneously into a pond, than when fingerling catfish were stocked after the bass had reached predatory size. In ponds containing predators, largemouth bass are usually considered the most destructive, but depending on size of catfish, large bluegill or even predaceous insects (Marzolf 1957) may be important predators. The impact of a predator is obviously determined by relative size of predator versus size of prey. Lawrence (1958) determined the maximum size of several different species of fish that largemouth bass of various sizes could theoretically swallow. Optimal foraging theory assumes that predators will in effect consume the largest prey that they can ingest, but in actuality predators usually forage most heavily on prey smaller than the theoretical maximum (Adams et al. 1982).

One complicating factor in the interaction between stocked catfish and predators is abundance of other forage populations. For example competition with forage fish (Scott and Crossman 1973 and Devaraj 1976) may slow the growth rate of catfish and thereby lengthen time of vulnerablity to predatory fish. At the same time, by providing an alternative food source, high densities of other forage can buffer predation on the catfish.

Physical factors or conditions of the ponds themselves such as turbidity, vegetative cover, water level fluctuations, area and depth may also affect catfish survival. For example Marzolf (1957) suggested that survival of indigenous populations of channel catfish was related to turbidity. In ponds having other species of fish and a Secchi disk reading of 20 inches (50 cm) or less, survival showed a positive correlation with Secchi readings. Channel catfish actually grow best at moderate levels of turbidity but high turbidity may provide cover from predators. The primary predators of catfish, largemouth bass and sunfish, are capable of tolerating short periods of high turbidity but grow and reproduce poorly (Wallen 1951 and Pflieger 1975) and presumably would have decreased feeding efficiency under these conditions.

Vegetative cover may also have important effects on catfish survival. Generally, highly vegetated ponds are not considered "good" habitat for fry because vegetation houses numerous predators (Marzolf 1957). However vegetation may also shelter high densities of small sunfish, crayfish, and insects which buffer catfish against predation. Also by providing attractive cover for the predators, vegetation may lure them away from areas of high catfish concentrations and indirectly enhance catfish survival.

Water level fluctuations and pond physiognomy are probably important in affecting channel catfish survival. Sharp drops in water level concentrate fish in a pool devoid of cover and ensure that bass and catfish are closely associated. Also increased surface area and pond depth might cause separation of catfish from bass and decrease chances of contact.

CHAPTER II

OBJECTIVES

The study had four objectives: (1) to study survival of newly hatched channel catfish fry in both barren ponds and in ponds containing other fish species; (2) to study survival of different sizes of catfish fingerlings in ponds with selected ratios of largemouth bass and sunfish; (3) to relate information on survival of fry and fingerlings to physical and biological factors of the pond (surface area, depth, turbidity, vegatative cover, channel catfish size, rate of growth, predator fish populations, and prey fish populations); and (4) to make management recommendations for channel catfish in ponds on the Fort Sill Military Reservation.

The study was carried out in three phases. Phase one (summer 1980) was a preliminary effort to obtain information on the biological and physical conditions in Fort Sill Ponds. Phase two dealt with evaluating survival of channel catfish fry. Phase three dealt with evaluating survival of fingerlings. Phase two and phase three occurred simultaneously (summers of 1981 and 1982).

CHAPTER III

RESEARCH AREA

The Fort Sill Military Reservation is located near Lawton, Comanche County in southwest Oklahoma. Fort Sill consists of 38,850 hectares of open grasslands, wooded hills, and mountains. Extremes in summer and winter temperatures and precipitation are common. Fort Sill has more than 200 ponds, over 150 which have fish populations (typically largemouth bass, *Micropterus salmoides*, bluegill, *Lepomis macrochirus*, redear sunfish, *Lepomis microlophus*, green sunfish, *Lepomis cyanellus*, and golden shiner, *Notemigonus chrysoleucas*). Most ponds have less than one hectare of surface area, are not more than five meters total depth, contain vegetation ranging from weed-free to weed-choked, bottom substrates ranging from boulders to fine silt, water transparency ranging from clear to very turbid; and typically show thermal stratification in the summer (surface temperatures may reach 32.2 C).

CHAPTER IV

PHASE ONE-PRELIMINARY STUDY

Materials and Methods

In a preliminary study the fish populations in five ponds were sampled by gillnetting, seining, and electroshocking. Experimental gill nets, 30.5 by 1.2 meters, with five graduated mesh sizes, were set in each pond from 3-8 days throughout the summer of 1980. A unit of effort was defined as three nets set for one night in one pond. The weight to the nearest gram and total length to the nearest millimeter were recorded for each catfish captured. Condition (K) factors were calculated by the formula

$$K = (W \times 100{,}000) / TL^3 \qquad (1)$$

(where W is weight of the catfish in grams and TL is total length in millimeters). Largemouth Bass and sunfish populations were sampled at night with a boat mounted electroshocking unit. A unit of effort was defined as one pass around the perimeter of the pond. All fish were released after recording total length to the nearest centimeter and weight to the nearest gram. Some ponds were also sampled with 4.5 and 9.1 meter seines.

Larval fish were collected (2-4 samples per pond) by using a 0.5 meter larval tow net with an attached flow meter to determine volume of water sampled. All samples were labeled and preserved in formalin. Zooplankton were sampled with a 30-centimeter zooplankton net equipped with a flow meter. Turbidity was recorded to the nearest centimeter with a Secchi disk. Temperature and dissolved oxygen were measured by using a portable dissolved oxygen meter.

Results

In spite of yearly (1977-1979) stocking of fingerlings, few channel catfish were found (Table I) and there was no evidence of natural reproduction. Catfish greater than 340 mm from Engineer Pond and all other catfish collected had a mean K factor of 0.97. Catfish smaller than 340 mm (total length) from Engineer Pond had an average condition factor of only 0.68. All condition factors (Table II) fell between the levels deemed normal by Carlander (1969). However a length-freguency distribution for those catfish from Engineer Pond smaller than 340 mm TL (Figure 1) showed that mean lengths of each year class corresponded more closely with the mean lengths of stunted catfish populations than with the state average (Figure 2).

No radical physical conditions were found in Fort Sill ponds that could explain the absence of catfish survival or reproduction. Throughout the summer all ponds had decreasing oxygen levels (Table III), increasing levels of turbidity (Table IV), and were thermally stratified (Table V).

Table I. Area (hectares), number of channel catfish stocked since 1977, and number recaptured in 1980 in the five study ponds.

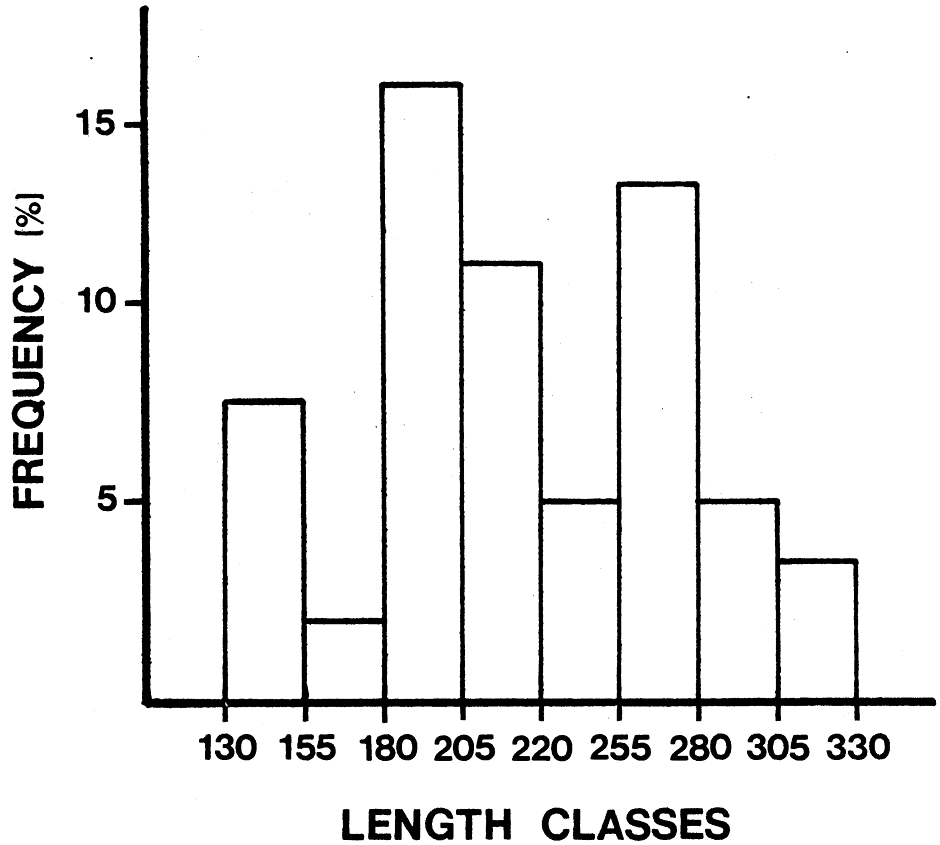
POND	Area	Number Stocked	Number Recaptured
Love	1.0	50	3
Logan	4.0	600	4
Engineer	10.0	3300	67
Quanah	0.8	700	1
Natches	0.3	300	0

Table II. Lengths (mm), weights (g), and condition factors (K) of channel catfish captured during 1980.

Pond	Total Length (mm)	Weight (g)	K
Love			
	170	60	1.22
	560	1500	0.85
	610	2325	1.02
Logan			
	85	9	1.46
	290	190	0.78
	285	205	0.89
	380	425	0.77
Engineer			
	430	620	0.78
	492	1000	0.84
	520	1150	0.82
	523	1325	0.93
Quanah			
	580	2450	1.26
Natches	No channel catfish captured		

Figure 1. Length-frequency distribution of channel catfish (< 340 mm) from Engineer Pond in 1980.

Figure 2. Average growth of channel catfish in Engineer Pond, five Oklahoma ponds, and the state average.


FREQUENCY [%]
15
10
5
130 155 180 205 220 255 280 305 330
LENGTH CLASSES

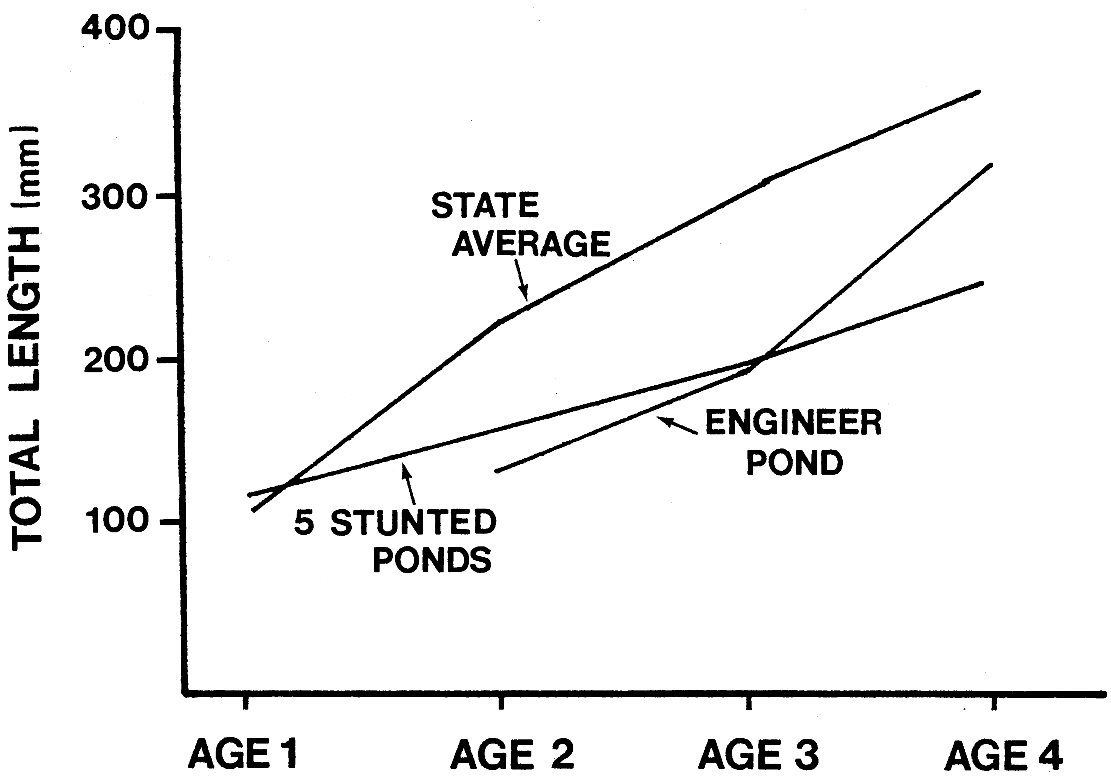

TOTAL LENGTH (mm)
400
300
200
100
STATE AVERAGE
ENGINEER POND
5 STUNTED PONDS
AGE 1
AGE 2
AGE 3
AGE 4

Table III. Dissolved oxygen concentrations (mg/l) for all ponds for July and August, 1980.

Pond Date	0.0	.75	1.5	Depth (meters) 2.25	3.0	3.75	4.5
Love							
July 10	6.2		6.0	4.2	1.9		
July 26	7.1	7.1	5.4	3.0	1.6		
Logan							
July 10	7.3		5.0	1.2(2.4 m)			
July 25	7.1	5.5	5.2	4.1	2.0(2.4 m)		
Engineer							
July 10	6.0		5.2		4.5		1.1
July 25	6.1	5.8	5.4	4.7	4.2	1.4	
August 8	7.0	6.3	6.3	6.2	6.1		4.0
Quanah							
July 10	7.1		6.5		1.0		
July 24	6.9	5.8	5.1	2.8	1.7		
August 8	5.5	5.0	5.0	3.0	1.1		
Natches							
July 10	6.1		3.5	1.0(2.0 m)			
July 25	5.2	4.9	4.2	1.0(2.0 m)			
August 8	6.0	4.3	4.0	1.0(2.0 m)			

Table IV. Secchi disk readings (centimeters) for all ponds for July and August, 1980.

Pond	July 10	July 24	August 8
Love	90	95	50
Logan	30	25	25
Engineer	80	45	25
Quanah	155	160	125
Natches	90	75	30

Table V. Water temperature (°C) of study ponds at selected depths for July and August, 1980.

Pond Date	Depth (meters) 0.0	0.75	1.5	2.5	3.0	3.75	4.5
Love							
July 10	31.1		30.6	28.3	26.1		
July 26	30.6	30.0	27.8	26.1	23.9		
Logan							
July 10	31.1		28.3		25.6(2.45 m)		
July 25	27.8	25.6	25.6	25.6	25.6(2.5 m)		
Engineer							
July 10	28.9		26.7		26.1		20.0
July 25	27.8	26.7	25.6	25.6	25.6	23.9	
August 8	26.7	25.6	25.6	24.4	24.4		23.3
Quanah							
July 10	32.2		29.4		21.1		
July 24	30.0	29.4	27.8	26.7	22.2		
August 7	29.4	28.9	26.7	26.7	23.9		
Natches							
July 10	31.7		29.4	24.4(1.8 m)			
July 25	29.4	28.3	27.8	25.0(2.1 m)			
August 8	29.4	28.9	26.7	26.1(2.1 m)			

Discussion

The general absence of catfish in Fort Sill ponds seems to indicate that yearly catfish stocking had been wasted effort in most ponds. Possible causes of high mortality are predation or starvation associated with inter-or intra-specific competition (Finnell and Jenkins 1954). The data on catfish growth rates would suggest that food availability may preclude acceptable growth rates in some ponds on Fort Sill (such as Engineer Pond). Another important limitation is the lack of natural reproduction. From the data obtained it is impossible to determine whether lack of reproduction results from very low numbers of adult channel catfish or from predation from existing fish populations.

It is clear, however, that physical conditions do not preclude catfish survival. Dissolved oxygen (Table III) and water temperature (Table V) did not reach levels lethal for channel catfish (Moss and Scott 1961) and the turbidities observed (Table IV) were not detrimental and may even be beneficial (Marzolf 1957).

CHAPTER V

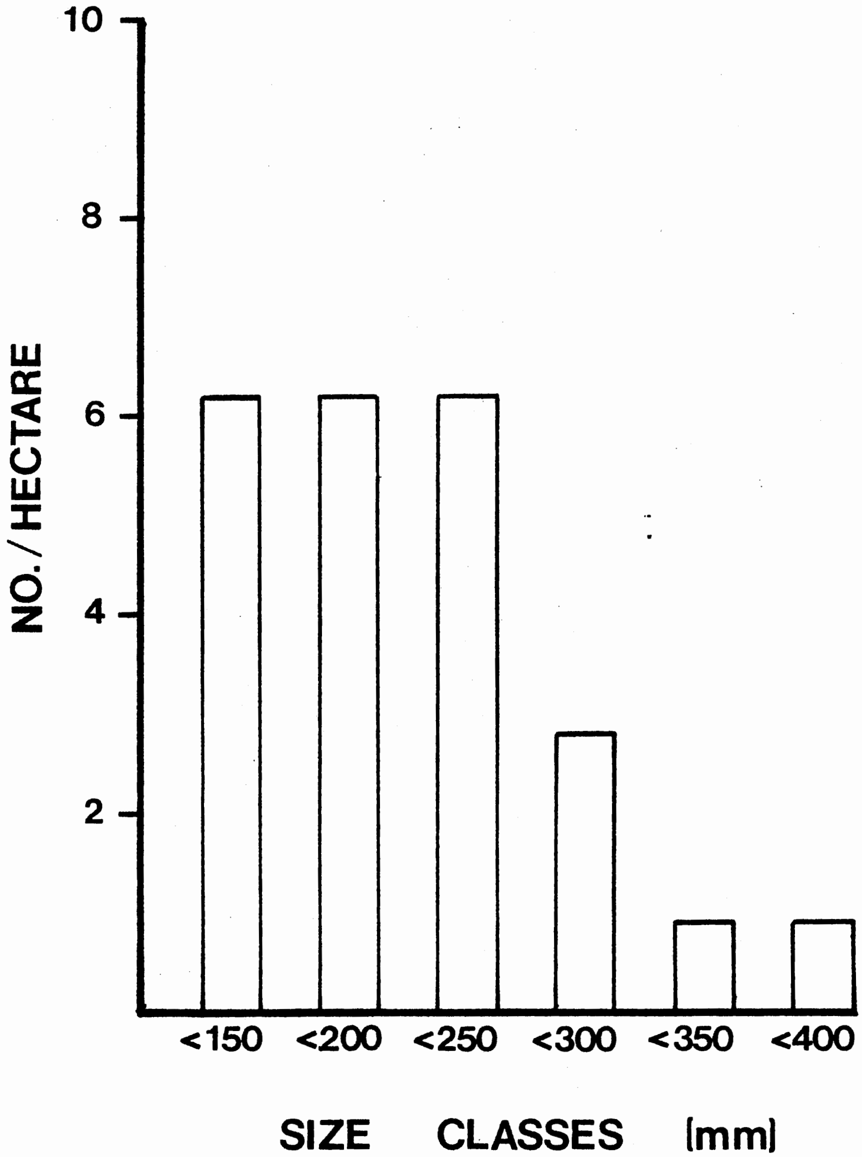
PHASE TWO-FRY SURVIVAL

Materials and Methods

Channel catfish fry (yolk sac and swim up) from Tishomingo National Fish Hatchery were stocked in virgin ponds, virgin ponds that had been restocked with measured ratios of largemouth bass, bluegill, redear sunfish, and green sunfish, and in ponds with existing populations of those species. In 1981, yolk-sac fry at 48 fish/gram (21,792 fish/pound), were stocked into one virgin pond and one pond containing introduced ratios of fish. Swim-up fry, 30 fish/gram (13,600 fish/pound), were stocked into two virgin ponds, two ponds containing introduced populations of fish, and three ponds with existing fish populations. The fry were stocked at densities ranging from 12,500-25,000 fry/hectare. In 1982, 13 mm swim-up fry were stocked in three ponds at the rate of 37,500 to 50,000 catfish/hectare. These three ponds (detailed descriptions of the three ponds used during 1982 are given in the Appendix) had been stocked with sunfish at the rate of 1000/hectare and bass according to a standard length distribution (Figure 3).

Sampling was done with small mesh seines (.3 cm and .6 cm) up to 21.3 meter in length, gill nets, larval traps, minnow traps, and electroshocking. Nine of the ponds were rotenoned. Sampling small channel catfish is difficult (Marzolf 1957) and rotenoning was the only

Figure 3. Length-frequency distribution for largemouth bass stocked in ponds on Fort Sill in 1982.


10
8
6
4
2
NO. / HECTARE
<150
<200
<250
<300
<350
<400
SIZE CLASSES (mm)

feasible method available of estimating total survival. Other techniques were ineffective because the ponds could not be drained and lacked suitable seining sites. Those ponds rotenoned included both ponds that had been stocked with yolk-sac fry, both of the virgin ponds stocked with swim up fry and the five ponds containing introduced populations of fish. All channel catfish recovered were preserved and all other species were counted and enumerated by size classes.

Results

In 1981 there was better survival of: a) swim-up fry than yolk-sac fry in virgin ponds and ponds stocked with other fish, b) of both fry types in the virgin ponds than those stocked with other fish, and c) no survival in ponds containing previously existing fish populations (Table VI). In 1982 here was no survival of swim-up fry which were stocked in ponds that contained populations of bass and sunfish (Table VI).

The rate of growth of the catfish fry was determined by calculating a length-weight regression for all recaptured fry. The regression was:

$$\log W = -5.269 + 3.12 \times \log TL \qquad (2)$$

and had and $r = 0.989$.

A Wilcoxon Rank Sums Test (Conover 1980) showed that mean daily weight increase was significantly higher ($P = 0.001$) in virgin ponds than in those ponds containing other fish species. The condition factors of the channel catfish fry sampled ranged from 0.72 to 1.30 with a mean of .95 (Table VI).

Table VI. Type of channel catfish fry stocked, type of pond stocked (V-virgin pond, I-introduced and E-existing predator populations), date stocked, number of fry stocked, number recaptured, mean weight (W) (grams) of fry at stocking, mean weight at rotenoning, mean daily growth (grams/day), and mean condition (K) for ponds on Fort Sill.

Year Pond	Date	# Stocked # Recaptured	W-stocking W-rotenoning	Mean daily growth	Mean condition
1981					
Yolk-sac					
Airfield-V	June 21 July 17	2500 5	0.0208 2.715	0.10	1.09
West Gypsy-I	June 21 August 12	1500 1	0.0208 3.63	0.07	0.87
Swim-up					
Quawpa-V	June 24 August 6	3000 50	0.034 12.97	0.28	0.95
Yurak-V	June 21 October 1	1600 106	0.034 66.7	0.07	0.86
Lower Strange-I	June 24 August 12	3000 24	0.034 3.63	0.07	0.87
Weed-I	June 24	3600 0	0.034 August 19, 1982		
Winnebago-E	June 24	2500 0	0.034 September 29, 1982		
Rocket-E	June 21	6000 0	0.034 Never Rotenoned		
Duck-E	June 21	3700 0	0.034 Never Rotenoned		
1982					
Swim-up					
West Gypsy-I	June 28 August 19	5000 0	0.03		
East Gypsy-I	June 28 August 19	15000 0	0.03		
Weed-I	June 28 August 19	12000 0	0.03		

Discussion

Large numbers of aquatic insects were captured while seining virgin ponds. Some aquatic insects are known to be predators on catfish fry (McGinty 1980) and high densities of these species probably contributed to the high mortality. High mortality in the ponds containing fish populations was probably due to fish predation (fish considered to be predators on fry were sunfish > 200 mm and all bass > 44 mm). All three ponds stocked with fry in 1982 had a large number of predator-size fish (Figures 4 and 5;A-C) and limited alternate forage (Figure 5;A-C). Although limited survival occurred in the three virgin ponds and in some of the ponds containing introduced predator fish populations, only in the virgin ponds was survival sufficient to provide what would be considered adequate year classes of channel catfish for fisherman.

Daily growth of fry was equal to or greater than that found in a Kansas study (Tiemeier and Deyoe 1980). Since growth was significantly greater in virgin ponds, interspecific competition seems to be occurring in ponds with existing fish populations. As anticipated from the growth data, condition of catfish was lower in ponds containing other species of fish. However even in the latter ponds, condition factors were still comparable to those of channel catfish fingerlings in Kansas ponds (Table VI) (Carlander 1969).

Figure 4. Number of sunfish > 200 mm actually recovered and estimated number per hectare for the three ponds stocked with fry in 1982.

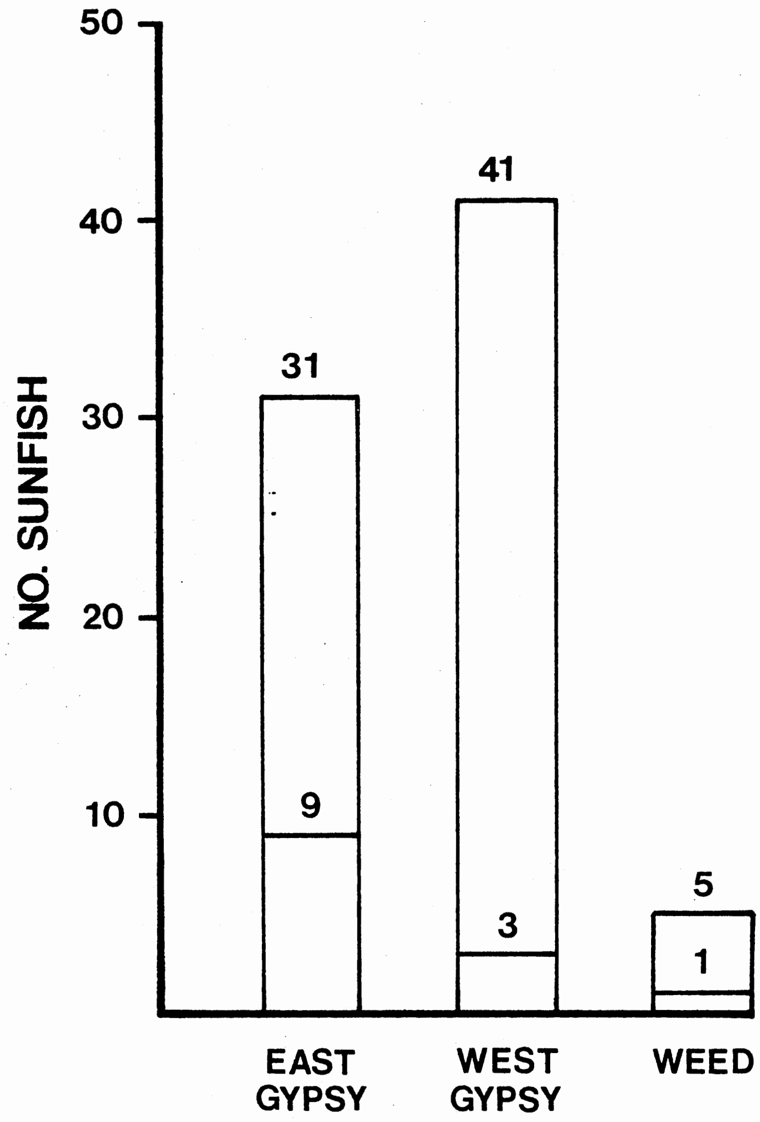
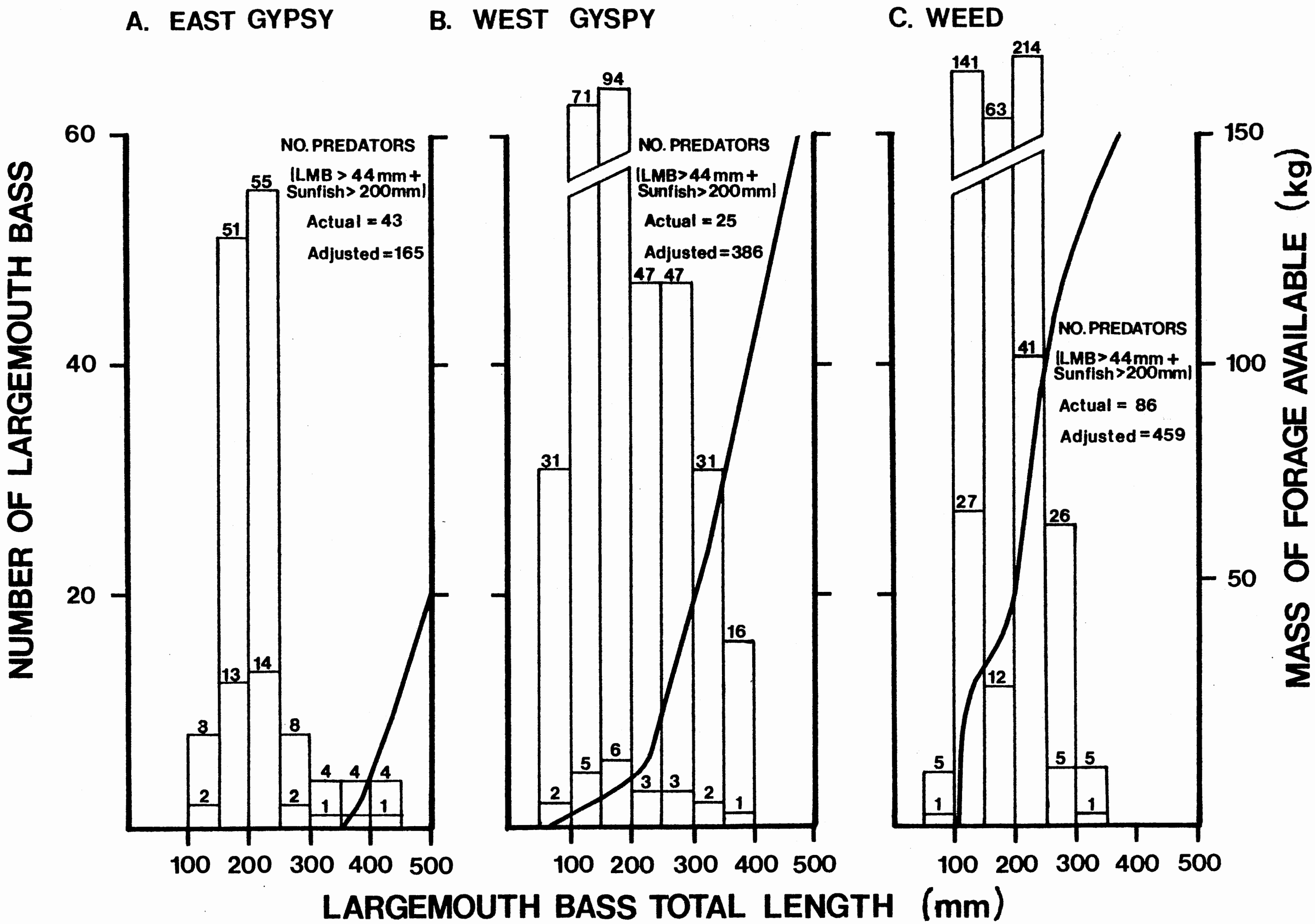

50
40
30
20
10
NO. SUNFISH
41
31
9
3
5
1
EAST
GYPSY
WEST
GYPSY
WEED

Figure 5. Status of populations of potential predators and potential prey, theoretical predator size, and numbers in 12 ponds on Fort Sill Military Reservation (A. East Gypsy Pond, B. West Gypsy Pond, and C. Weed Pond).


A. EAST GYPSY
B. WEST GYSPY
C. WEED
NUMBER OF LARGEMOUTH BASS
MASS OF FORAGE AVAILABLE (kg)
LARGEMOUTH BASS TOTAL LENGTH (mm)
NO. PREDATORS (LMB > 44 mm + Sunfish > 200 mm)
Actual = 43
Adjusted = 165
NO. PREDATORS (LMB > 44 mm + Sunfish > 200 mm)
Actual = 25
Adjusted = 386
NO. PREDATORS (LMB > 44 mm + Sunfish > 200 mm)
Actual = 86
Adjusted = 459
0
20
40
60
50
100
150
100 200 300 400 500

CHAPTER VI

PHASE THREE-FINGERLING SURVIVAL STUDY

Materials and Methods

In 1981 channel catfish fingerlings ranging in length from 125 to 220 mm were stocked in five ponds at densities of 600 fish/hectare. Three of the ponds contained existing populations of largemouth bass, bluegill, redear sunfish, and green sunfish. One of these ponds also contained a large number of golden shiners. The remaining two ponds were virgin ponds and were stocked with various combinations of largemouth bass, bluegill, redear sunfish, and green sunfish. All of the ponds were less than 1 hectare in surface area, ranged in depth from 2 to 5 meters, and had Secchi disk readings less than 90 cm.

The ponds containing natural populations of fish were sampled with small mesh (1.9 cm) gill nets, 2.4 m x 30.5 m. The ponds containing stocked ratios of fish were sampled with gill nets and then were rotenoned, one pond 6 weeks after stocking and the other after 12 weeks. All fish taken in gill nets were weighed and measured and those in good shape were either tagged or fin clipped and released. Channel catfish recovered after rotenoning were also weighed and measured. The ratio of capture by the two techniques was used to evaluate sampling efficiency. Largemouth bass recovered were measured.

Nine ponds were stocked with catfish fingerlings during 1982. Ponds which contained fish were first surveyed by using a boat mounted electroshocking unit. If sunfish were absent they (bluegill, redear, and green sunfish) were stocked at the rate of 1000 per hectare; if present in low densities they were stocked to approximate 1000 fish per hectare. Largemouth bass were stocked, if needed to reach a standard length distribution (Figure 3) per hectare. Sunfish were stocked early in the spring prior to the bass to encourage sunfish reproduction. Following the stocking of predator populations, three replicate ponds were stocked with each of the four sizes of channel catfish; a single size per pond. These fingerling stocking densities were, 75-mm catfish at approximately 10,000 fish/hectare, 115-mm catfish at 1,150 to 1,500 fish/hectare, and the 150-mm catfish at 450 to 550 fish per hectare. The fish were left in the ponds until the end of summer and the ponds were then rotenoned (detailed descriptions of the nine ponds used in 1982 are given in the Appendix).

Previous authors have found that 90% of the channel catfish present can be recovered by rotenoning (Axon et al. 1979). To test this hypothesis one hundred catfish were marked and released in Lower Strange Pond. Three days later they were rotenoned and 89 were recovered. Eighty nine percent was used as the sampling efficiency for rotenone and adjusted survival was based on this percentage (recovery of tagged catfish was not feasible because no tagged catfish were recovered). Observations were placed on an 80-day basis and constant mortality was assumed (Table XIII) to allow comparisons between different ponds. Such an approach was necessary because fingerlings of different sizes were stocked at different times as they became available from the hatchery.

Weights and total lengths were recorded for all channel catfish collected. Largemouth bass collected were also measured for total lenghts. Subsamples of sunfish were measured for lengths, and all other species were counted. Secchi disk readings were taken in 1982 at the time of stocking, at least once while the channel catfish were in the pond, and again at the time of rotenoning.

To evaluate bass predation, largemouth bass stomach contents were sampled in two of the ponds stocked in 1982 with 75-mm channel catfish. The bass were collected immediately after dark using a boat mounted electroshocking unit. Bass lengths were recorded, stomach contents were removed by using glass tubes (Gilliland et al. 1982), and the bass were released. The stomach contents were labeled and preserved and all samples were examined for identifiable prey items.

Previous authors have found that 66-67% of marked bluegill and 73-75% of marked bass can be recaptured in ponds in the midwest using rotenone (Reynolds and Simpson 1978). In seven ponds, largemouth bass and/or sunfish were collected by electroshocking the night before the pond was to be rotenoned, and fin clipped by removal of the left pelvic fin. During rotenoning all fin clipped fish recovered were counted and an average rotenoning efficiency for both bass and sunfish was determined by averaging the percent of the marked largemouth bass and sunfish recovered. This number was used in calculating adjusted numbers and biomass per hectare for all twelve ponds stocked in 1982.

Lawrence (1957) previously used body depth measurements of sunfish bass, and golden shiners to develop estimates of theoretical maximum forage size. However channel catfish are more rounded than sunfish and it was decided to use pelvic girdle diameter (= maximum width) rather than depth to define maximum forage size. The regression of total length on pelvic girdle diameter was:

$$PG = -0.1963 + (0.1512 * TL) \tag{3}$$

(where PG is the pelvic girdle measurement in mm and TL is the total length of the catfish in mm), and $r = 0.9586$. This regression is significant at the 1% confidence level. During the food habits study, the largest tube that would slide into each bass stomach was determined. It was hypothesized that this tube would be very near the maximal pelvic girdle diameter that the bass could ingest. The regression relating total length of bass to maximum diameter of ingestible tube (= pelvic girdle diameter) is:

$$TUBE = -2.5512 + (0.0998 * TL) \tag{4}$$

(where TUBE is tube diameter and TL is bass total length). Using regression equations (3) and (4) and the assumption that maximum ingestable tube and pelvic girdle diameters are equivalent, the following mathematical function was developed which related total length of bass (predator) to total length of catfish:

$$LMBTL = 23.5962 + (1.515 * CCTL) \tag{5}$$

Using Lawrence's measurements the following function was developed between total length of bass (predator) total length of bluegill (prey):

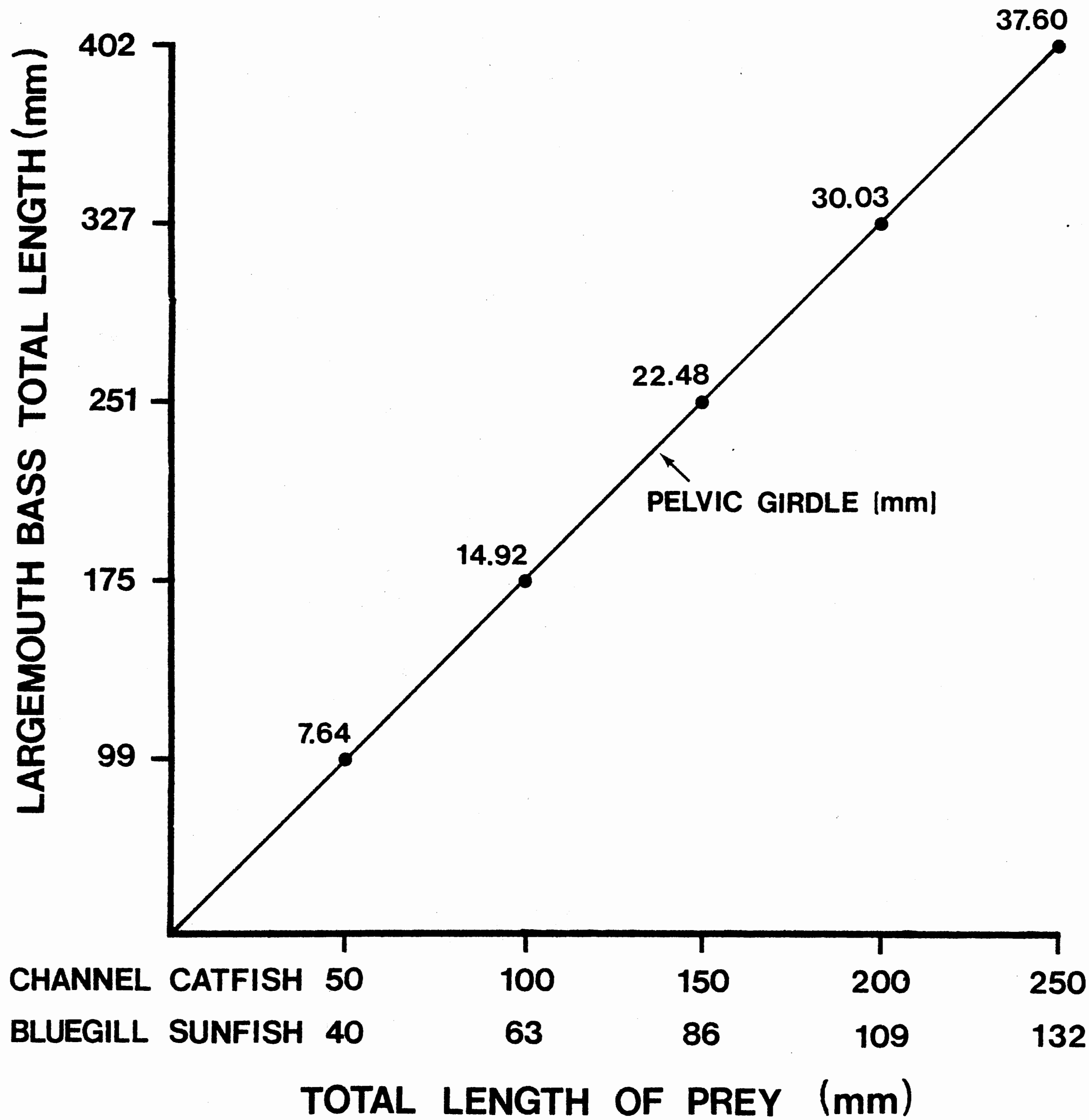
$$LMBTL = -35.2493 + (3.3245 \quad * BGTL) \tag{6}$$

These relationships between predator size and theoretical prey size are shown graphically (Figure 6).

Results

The equation relating catfish length to bass length was used to determine the number of predators (only bass were considered to be predators because sunfish were not large enough to consume catfish

Figure 6. Relationship of total length of channel catfish and bluegill (theoretical prey) to total length of largemouth bass (theoretical predators).


37.60
402
327
251
175
99
30.03
22.48
14.92
7.64
PELVIC GIRDLE (mm)
LARGEMOUTH BASS TOTAL LENGTH (mm)
CHANNEL CATFISH 50 100 150 200 250
BLUEGILL SUNFISH 40 63 86 109 132
TOTAL LENGTH OF PREY (mm)

fingerlings) for each size catfish in a pond (Figures 7;A & B and 8;D-L). All bass capable of consuming a catfish were considered available predators. Available forage fish for these predators was calculated based on size relationships (Figure 8;D-L). The relationship between bass length and bluegill length was used to determine the cumulative weight of available forage. Fish were placed in 10-cm size classes and the weight of the sunfish, bass, and golden shiners (prey) was summed for each size class.

The regression of catfish total length (Table VII) on catfish survival (Table VIII) for all 12 ponds stocked in 1982 was:

$$TL = 66.2193 + (0.6998 * \text{Survival}) \qquad (7)$$

r = 0.4739. This regression is not significant at the 10% level. However removal of Quawpa Pond data resulted in an r = 0.6479:

$$TL = 59.3234 + (1.1735 * \text{Survival}) \qquad (8)$$

which is significant between the 5 and 2% level. This equation showed that stocked channel catfish less than 59.3 mm in total length would have a predicted survival of 0% after 80 days and that those stocked at a size larger than 176.7 mm would have 100% survival after 80 days. When data from Lower Rabbit and Quawpa Ponds are removed the regression became:

$$TL = 43.5859 + (1.4253 * \text{Survival}) \qquad (9)$$

r = 0.806. This equation is significant at the 1% confidence level. In this equation catfish 43.6 mm in length would have 0% survival and those 186.1 mm in length would have 100% survival after 80 days.

Growth was studied to determine how long the catfish would actually be susceptible to predation and as a means of checking suitability of habitat. The weight-day regression equation was:

$$\log W = 1.533 + .147 \times \log D \qquad (10)$$

Figure 7. Predator populations in two ponds on Fort Sill Military Reservation (A. Lower Strange Pond and B. Mesquite Pond).

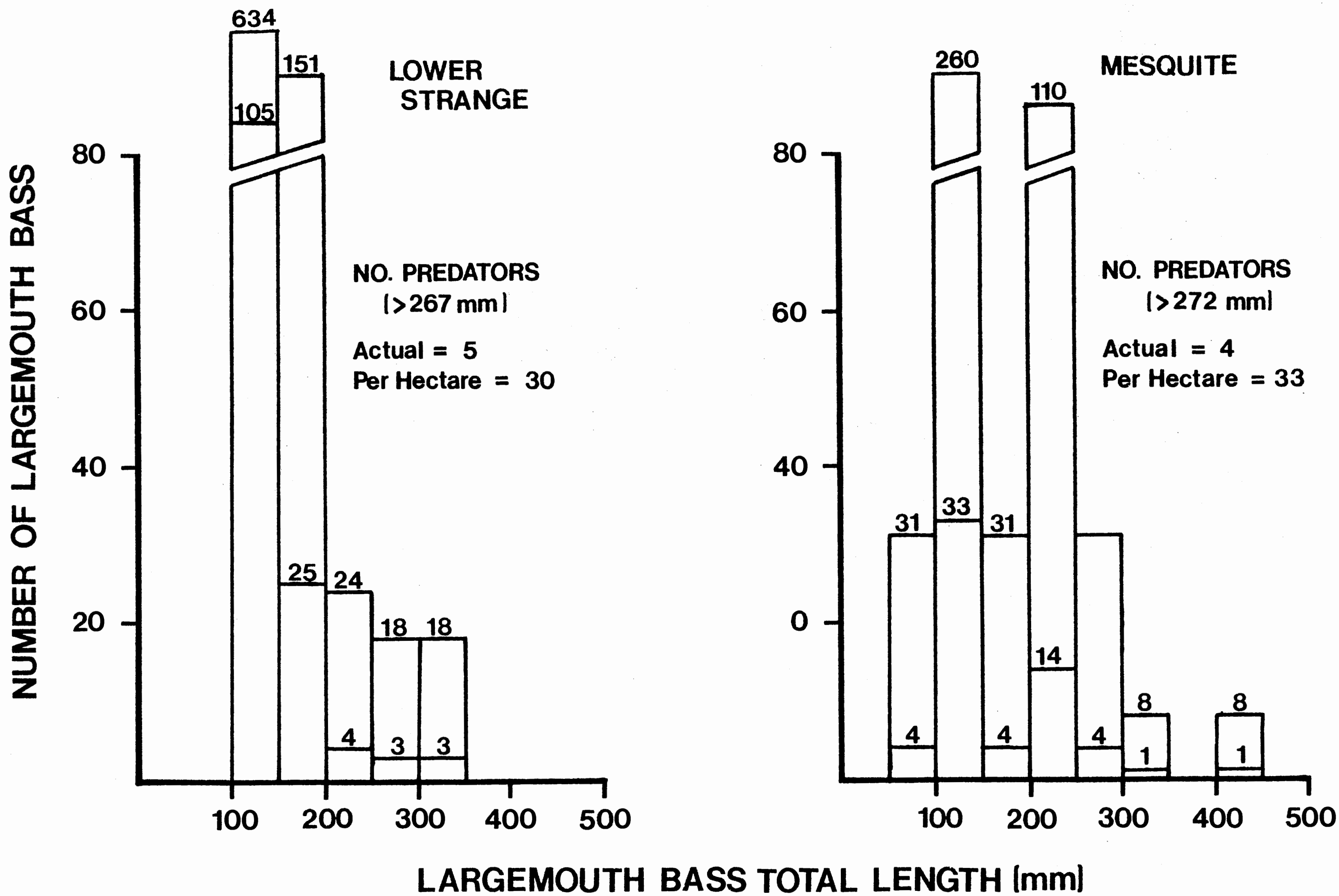
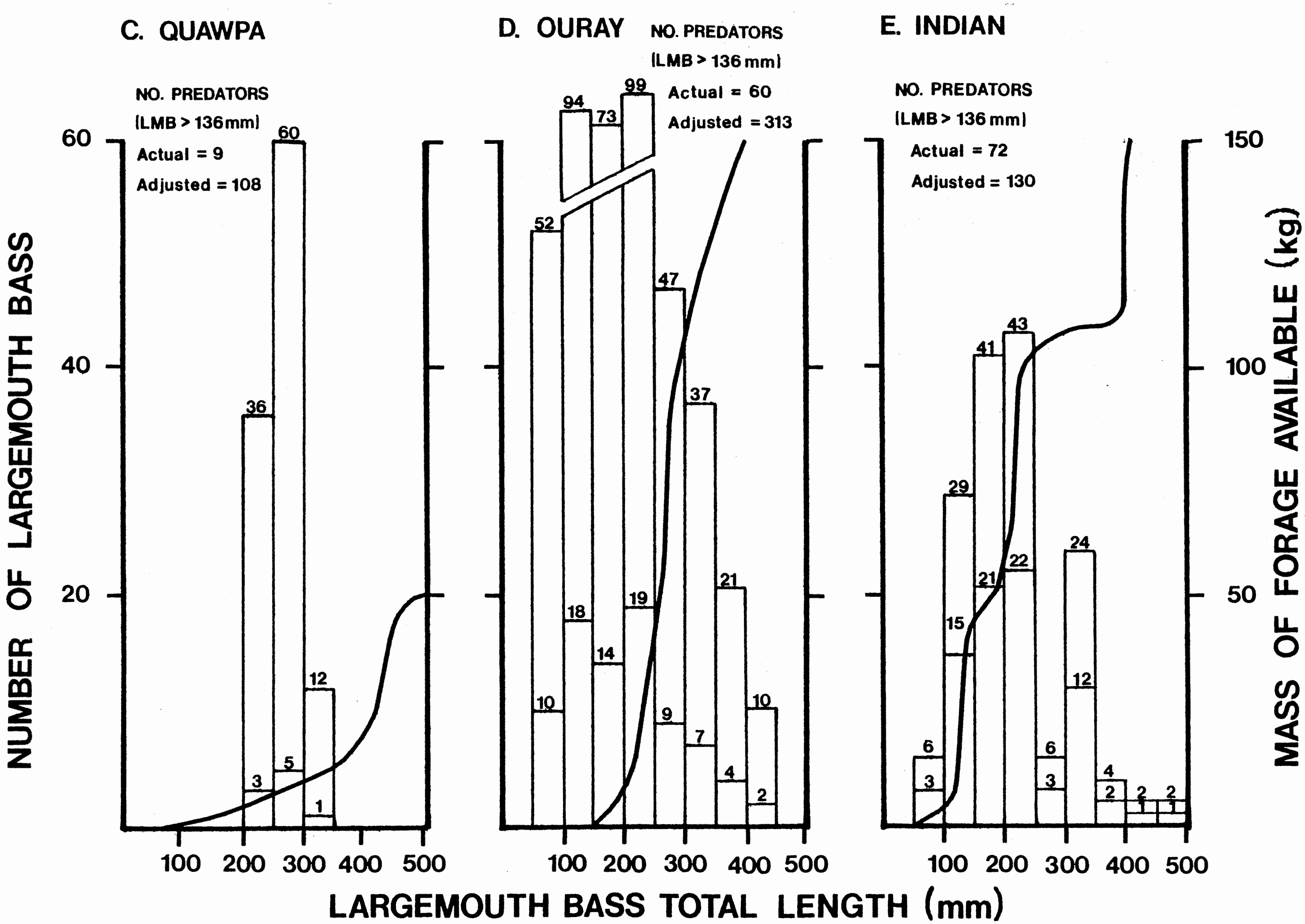
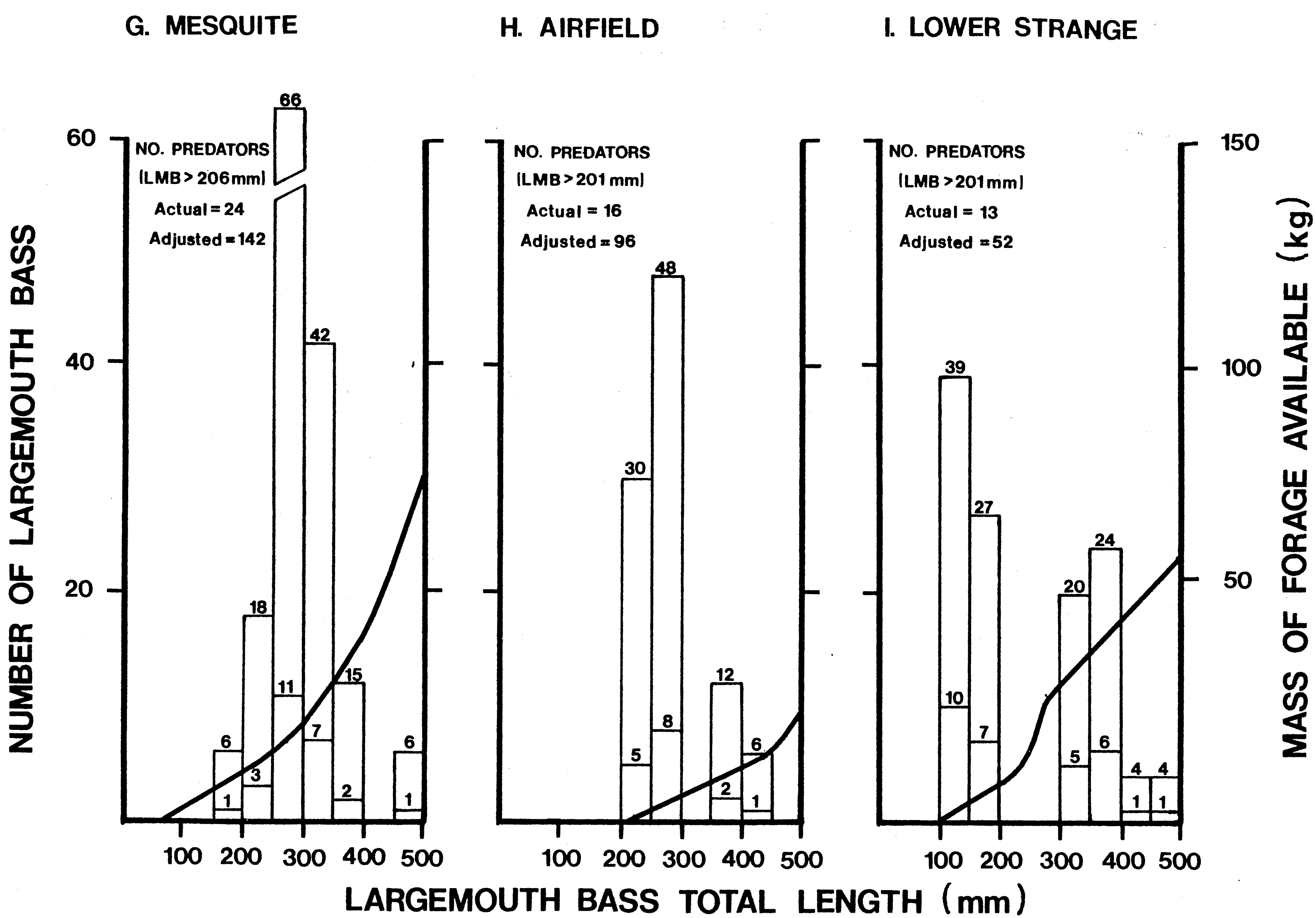

LOWER STRANGE
MESQUITE
634
151
105
25
24
18
18
4
3
3
260
110
31
33
31
14
4
4
4
8
8
1
1
NO. PREDATORS (>267 mm)
Actual = 5
Per Hectare = 30
NO. PREDATORS (>272 mm)
Actual = 4
Per Hectare = 33
NUMBER OF LARGEMOUTH BASS
80
60
40
20
0
100
200
300
400
500
LARGEMOUTH BASS TOTAL LENGTH (mm)

Figure 8. Status of populations of potential predators and potential prey, theoretical predator size, and numbers in 12 ponds on Fort Sill Military Reservation (D. Quawpa Pond, E. Ouray Pond, and F. Indian Pond).



C. QUAWPA
NO. PREDATORS
(LMB > 136mm)
Actual = 9
Adjusted = 108
D. OURAY
NO. PREDATORS
(LMB > 136 mm)
Actual = 60
Adjusted = 313
E. INDIAN
NO. PREDATORS
(LMB > 136 mm)
Actual = 72
Adjusted = 130
NUMBER OF LARGEMOUTH BASS
MASS OF FORAGE AVAILABLE (kg)
LARGEMOUTH BASS TOTAL LENGTH (mm)

Figure 8. Continued (G. Airfield Pond, H. Mesquite Pond, and I. Lower Strange Pond).



G. MESQUITE
H. AIRFIELD
I. LOWER STRANGE
NO. PREDATORS (LMB > 206mm) Actual = 24 Adjusted = 142
NO. PREDATORS (LMB > 201 mm) Actual = 16 Adjusted = 96
NO. PREDATORS (LMB > 201mm) Actual = 13 Adjusted = 52
NUMBER OF LARGEMOUTH BASS
MASS OF FORAGE AVAILABLE (kg)
LARGEMOUTH BASS TOTAL LENGTH (mm)
0
20
40
60
50
100
150
100 200 300 400 500
66
42
18
15
11
7
6
6
3
2
1
1
48
30
12
8
6
5
2
1
39
27
24
20
10
7
6
5
4
4
1
1

Figure 8. Continued (J. Winnebago Pond, K. Lower Rabbit Pond, and L. Caddo Pond).

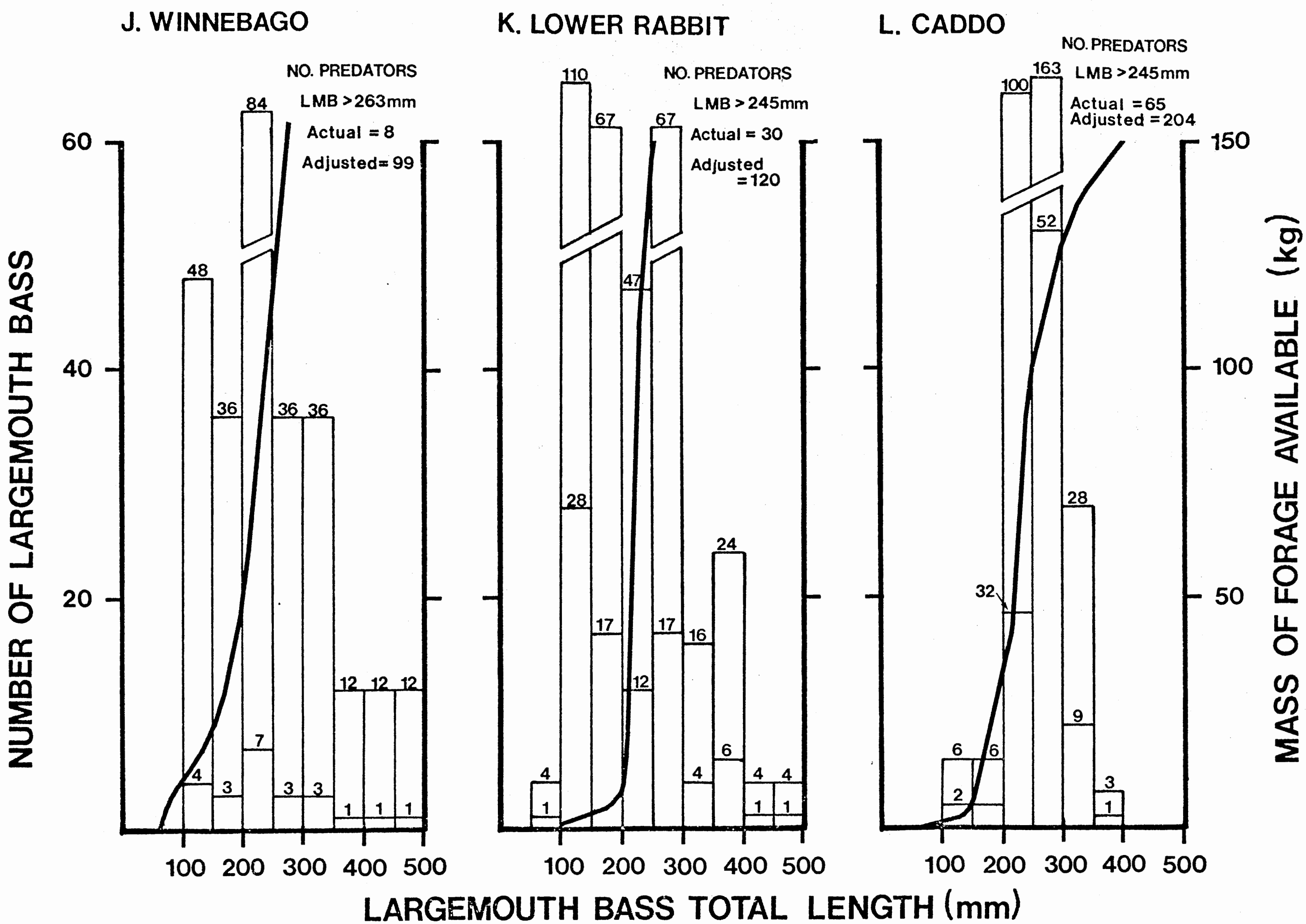

J. WINNEBAGO
NO. PREDATORS
LMB >263mm
Actual = 8
Adjusted= 99
K. LOWER RABBIT
NO. PREDATORS
LMB > 245mm
Actual = 30
Adjusted =120
L. CADDO
NO. PREDATORS
LMB >245mm
Actual =65
Adjusted =204
NUMBER OF LARGEMOUTH BASS
MASS OF FORAGE AVAILABLE (kg)
LARGEMOUTH BASS TOTAL LENGTH (mm)

Table VII. Pond area, time in days between stocking and harvest, length stocked, number stocked, number recovered, and percent survival of catfish in 11 ponds on Fort Sill.

Pond	Area (hectares)	Time (days)	Length at Stocking (mm)	Number Stocked	Number Recovered	% Survival
1981						
Lower Strange	0.2	47	164.1	60	46	76.7
Mesquite	0.26	94	160.8	180	155	86.1
1982						
Ouray	0.3	39	74.3	3000	233	7.8
Indian	0.8	39	74.3	8000	4294	53.7
Quawpa	0.13	39	74.3	1500	1463	97.5
Mesquite	0.26	82	120.6	466	111	23.8
Airfield	0.26	79	116.8	466	196	42.1
Lower Strange	0.4	74	116.8	466	297	63.7
Winnebago	0.13	124	158.1	60	2	3.3
Lower Rabbit	0.4	68	146.4	186	28	15.1
Caddo	0.5	75	146.4	275	218	79.3

(where W is the weight of the fish in grams and D is the number of days the catfish was in the pond) $r = .924$. This equation may have been biased by data from Rudd Pond which contained golden shiners. A Wilcoxin Rank Sums Test (Conover 1980) verified ($P = 0.001$) that mean daily weight increase of channel catfish in Rudd Pond was significantly greater than the mean daily weight increase of those in the other four ponds (Table IX) ($P = 0.001$). Therefore the weight-day regression equation was calculated without the Rudd Pond data. The correlation coefficient increased to $r = .995$, and the equation became:

$$\log W = 1.546 + .24 \times \log D. \qquad (11)$$

To determine if condition of fish was comparable on Fort Sill from year to year a length-weight regression was also calculated for all of the catfish taken in gill nets in 1981. This equation was:

$$\log W = -4.617 + 2.792 * \log TL \qquad (12)$$

(where W is the weight of the catfish in grams and TL the total length of the fish in mm) and the $r = 0.935$. The mean condition factors (0.50 to 1.38 with a mean of 0.84) for channel catfish fingerlings from both years (Table IX) falls within the range of condition factors given by Carlander (1969).

Growth rates of fish in individual study ponds varied over time. Growth during 1981 was relatively constant over time in fish in Rudd Pond but decreased over time in fish from Love and Mesquite Ponds (Table IX). Growth of fish was significantly lowere in 1982 than 1981. In 1982 only fish in Winnebago and Lower Rabbit had growth rates near those found in 1981 and these ponds had very low numbers of catfish present (Table VII). In all of the 1982 ponds except Lower Strange overall growth of stocked channel catfish was inversely related to total catfish survival (Table X).

Table VIII. Projected survival of catfish in 11 ponds on Fort Sill.

Pond	Days	Actual Number Stocked	Actual Number Recovered	Projected Survival	Projected Survival 80 Days	Adjusted Percentage Survival 80 Days
1981						
Lower Strange	47	60	46	52	46	76.7
Mesquite	94	180	155	174	175	97.2
1982						
Ouray	39	3000	233	261	0	0.0
Indian	39	8000	4294	4809	1454	18.2
Quawpa	40	1500	1463	1639	100	100.0
Mesquite	82	466	111	124	132	28.4
Airfield	79	466	196	220	217	46.6
Lower Strange	74	466	297	333	322	69.1
Winnebago	124	60	2	2	23	38.3
Lower Rabbit	68	186	28	31	4	2.2
Caddo	75	275	218	244	242	88.0

Recapture efficiency (at rotenoning) of fin clipped largemouth bass ranged from 46% for Lower Strange Pond up to 88% for East Gypsy Pond averaged 63.5% (Table XI). Sunfish recovery ranged from 53% in Ouray Pond up to 94% in East Gypsy Pond and averaged 72.5%. No recapture efficiency was determined for golden shiners because none had been marked. Actual recovery of introduced fish populations varied among ponds. Very few of both largemouth bass and sunfish were recovered from either Airfield Pond or Quawpa Pond, but large numbers (many young of year) were recovered from other ponds (Table XII). The number of golden shiners per hectare was estimated using the recovery percentage calculated for sunfish.

Predator numbers were compared between all 14 ponds by using the total predator number per hectare calculated for the particular size catfish stocked. The regression equation between channel catfish survival and the number of predators in each pond was:

$$\text{Predators} = 240.10 + (-1.814 * \text{Survival}) \qquad (14)$$

$r = -0.541$. This equation was significant between the 5 and 2% level. The correlation increased dramatically if data from Quawpa Pond and Lower Rabbit Pond were excluded from the analysis:

$$\text{Predators} = 293.59 + (-2.514 * \text{Survival}) \qquad (15)$$

$r = -0.6887$. This equation was significant between the 1 and 2% confidence level.

Largemouth bass began to prey on channel catfish the first day catfish were stocked, August 20, 1982 (Table XIII). In Ouray Pond channel catfish immediately became important in the diet but gradually declined in importance. In Indian Pond few catfish were initially eaten by the bass but the number steadily increased over time.

Table IX. Date of stocking , number of fish stocked, number recaptured, mean weight (grams) at stocking, mean weight at recapture, mean daily growth (grams/day), and mean condition (K) of channel catfish fingerlings mm) stocked in ponds on Fort Sill.

Pond	Date	# Stocked # Recaptured	W-stocking W-capture	Mean daily growth	Mean condition
1981					
Love	June 26	600	36.91		
	July 8	23	51.17	1.19	0.79
	July 28	16	59.40	0.41	0.78
Rudd	June 26	240	36.91		
	July 10	34	56.29	1.38	0.84
	August 12	11	97.55	1.53	0.89
Bobcat	June 30	360	34.92		
	July 30	2	58.50	0.79	0.70
Mesquite	June 30	180	34.92		
	July 31	17	56.67	0.70	0.83
	October 2	45	72.44	0.25	0.82
Lower Strange	June 26	60	36.92		
	August 12	21	63.90	0.57	0.78
1982					
Mesquite	May 28	466	10.95		
	August 17	111	27.00	0.20	0.86
Airfield	June 1	466	9.76		
	August 18	196	25.60	0.20	1.14
Lower Strange	June 1	466	9.76		
	August 13	297	30.51	0.28	0.81
Winnebago	May 27	60	22.78		
	September 29	2	155.00	1.07	0.88
Lower Rabbit	June 3	186	19.10		
	August 11	28	53.20	0.50	.92
Caddo	June 3	275	19.10		
	August 17	218	40.04	0.28	.79

Table X. Days between stocking and harvest, percent survival, average total length at stocking (mm), average total weight at stocking (grams), average total length at harvest, and average total weight at harvest of channel catfish in 11 ponds on Fort Sill.

Pond	Time (Days)	% Survival	$\bar{X}$ Total Length Stocking	$\bar{X}$ Total Weight Stocking	$\bar{X}$ Total Length Rotenoning	$\bar{X}$ Total Weight Rotenoning
1981						
Lower Strange	47	76.7	164.1	36.92	208.9	72.44
Mesquite	94	86.1	160.8	34.92	199.7	63.90
1982						
Ouray	39	7.8	74.3	2.58	82.3	3.38
Indian	39	53.7	74.3	2.58	78.6	3.08
Quawpa	39	97.5	74.3	2.58	75.6	2.71
Mesquite	82	23.8	120.6	10.95	148.2	27.00
Airfield	79	42.1	116.8	9.76	131.9	25.60
Lower Strange	74	63.7	116.8	9.76	155.2	30.51
Winnebago	124	3.3	158.1	22.78	260.0	725.00
Lower Rabbit	68	15.1	146.4	19.10	182.9	53.20
Caddo	75	79.3	146.4	19.10	174.6	40.04

Table XI. Number of largemouth bass marked and recovered for each pond, percent recovery of largemouth bass, number of sunfish marked and recovered, and percent recovery of sunfish in 1982.

Pond	Largemouth Bass Marked	Recovered	Percent	Sunfish Marked	Recovered	Percent
Indian	14	7	50	20	15	75
Ouray	11	8	73	15	8	53
Lower Strange	13	6	46	8	6	75
Lower Rabbit	20	15	75	25	18	72
Weed	8	4	50	5	3	60
East Gypsy	8	7	88	16	15	94
West Gypsy				20	14	70
Total	74	47	63.5	109	79	72.5

Table XII. Recovery of largemouth bass from 12 ponds on Fort Sill.

Pond	Area (hectares)	Number Recovered / Adjusted Per Hectare Largemouth Bass	Bluegill	Golden Shiners
1981				
Lower Strange	0.2	61/480	140/970	0
Mesquite	0.26	140/850	270/1440	0
1982				
Ouray	0.3	170/873	1410/6500	425/1600
Indian	0.8	81/159	26480/45680	675/950
Quawpa	0.13	9/109	420/4480	420/3600
Mesquite	0.26	1100/6643	970/5150	17/70
Airfield	0.26	16/97	3300/780	2/10
Lower Strange	0.4	760/2975	1180/4080	11/30
Winnebago	0.13	930/11168	3720/39410	0
Lower Rabbit	0.4	250/969	7950/27420	150/450
Caddo	0.5	110/355	10500/29000	110/250

Simple regressions between survival and physical factors were calculated using catfish survival as the dependent variable and area, depth, average turbidity, and percent surface vegetation as the independent variables (Table XIV). None of these regressions were significantly correlated with survival ($P = 0.10$).

Discussion

The data indicated that predation was the most important factor limiting fingerling channel catfish survival on Fort Sill Military Reservation. On page 14 it was argued that predation also limited fry survival on Fort Sill. Of course, the importance of predation to survival of stocked fish is known to fisheries biologists. Elrod (1971) compared survival between channel catfish fingerlings (? mm) stocked concurrently with juvenile predator populations to that of those stocked into existing fish populations. There was 46% nonfishing mortality after 46 months in the first case and 39% after only 10 months in the second case.

My study also showed that catfish survival was directly proportional to the number of potential predators (Equations 14 and 15). For example excellent survival (> 76.7%) was evident in Mesquite and Lower Strange Ponds in 1981 and Quawpa Pond in 1982 (Table VIII). These ponds had very low numbers (< 9) of predatory size bass. On the other hand survival was low (< 2.2%) in Ouray and Lower Rabbit Ponds where there were large numbers (> 30) of predatory size bas (Table VIII).

Size of catfish at stocking and predator size are important factors in the predator-prey interaction. Stocking catfish that are too too large to be consumed by predators appears to be the solution to the loss

Table XIII. Predation of largemouth bass on channel catfish.

Date Pond	Number of Stomachs	Percent of Stomach Samples With Food Item Catfish	Sunfish	Unid. Fish	Insects	Other	Empty
Aug 20							
Indian	14	14.3	28.6	35.7	7.2	14.3	0.0
Aug 21							
Indian	24	4.2	8.3	50.0	0.0	0.0	37.5
Ouray	24	45.8	4.2	16.7	8.3	8.3	16.7
Sept 1							
Indian	14	0.0	42.9	35.7	0.0	7.2	14.3
Ouray	26	26.9	11.5	23.1	0.0	3.9	34.6
Sept 8							
Indian	10	20.0	10.0	40.0	0.0	0.0	30.0
Ouray	18	11.1	33.3	11.1	11.1	5.6	27.8
Sept 15		Rain Event					
Sept 21							
Ouray	7	0.0	0.0	0.0	57.2	0.0	42.8
Sept 27							
Indian	11	27.3	27.3	0.0	0.0	0.0	45.6
Ouray	14	0.0	28.6	7.2	14.3	7.2	42.9

Table XIV. Physical parameters of 14 ponds on Fort Sill.

Date Pond	Area (hectares)	Maximum Depth (cm)	Secchi Disk Readings (cm) Stocking			Rotenoning	% Surface Weed
1981							
Lower Strange	0.2	350					0
Mesquite	0.26	300					25
1982							
East Gypsy	0.4	300	125	112		87	0
West Gypsy	0.1	144	144	144		144	10
Weed	0.3	400	157	114		93	25
Ouray	0.3	350	92	90	21	49	5
Indian	0.8	450	95	85	32	79	40
Quawpa	0.13	175	31	26		21	0
Mesquite	0.26	300	39	151		163	25
Airfield	0.26	300	4	7		32	0
Lower Strange	0.4	600	105	185		218	25
Winnebago	0.13	250	65	64		56	5
Lower Rabbit	0.4	350	40	75		77	5
Caddo	0.5	200	62	135	122	74	40

of fingerlings. In general the data showed that survival was correlated to length of stocked catfish ($P = 0.01$), (Equation 9) and one hundred percent survival was predicted for 186 mm catfish.

Another aspect of this predation equation was availability of alternate forage. Although there is some minimum biomass that must be present in ponds containing predators (bass) to provide sufficient forage, actual biomass is of secondary importance to factors such as availability, size, and acceptability of forage to the predator. For example studies have shown that larger bass prefer larger forage (Lawrence 1958; Tarrant 1960; Snow 1971; and Timmons and Pawaputanon 1980). In addition, differential preference for particular food items have been shown. Lewis and Helm (1964) showed that bass utilized bluegill less frequently than all other food items (green sunfish, black bullheads, golden shiners, gizzard shad, tilapia, tadpoles, crayfish, carp flathead minnows, and salamanders) and that black bullheads were preferred by especially larger bass (Lewis et al. 1961). This preference for catfish might indicate that channel catfish may be highly vulnerable to bass predation.

Examples of the affects that alternate forage had on catfish survival were marked in my study. Excellent survival occurred in Lower Strange Pond where there was little fish forage (Figure 8;I) but an enormous supply of tadpoles (> 10,000/hectare). In Indian and Caddo Ponds there were large numbers of suitably-sized forage and also excellent survival of catfish (Figure 8;I & L). Conversely in Ouray and Lower Rabbit Ponds there were low numbers of available forage and low survival of the catfish (Table VIII) (Figure 8;E & K).

Aquatic vegetation also affected the predation equation. The vegetation appeared to provide a refuge, which allowed the other forage to reproduce and reach the size where they will buffer predation on the catfish. Summers (1980) reported that forage-sized bluegill occurred primarily in the middle of dense vegetation which afforded protection from bass predation. In Indian and Caddo Ponds, vegetation may have allowed the development of large forage populations and resulted in high catfish survival (Figure 8;F & L). Absence of vegetation in Ouray and Lower Rabbit Ponds was associated with little available bass forage and low catfish survival (Figure 8;E & K). Vegetation also attracts bass (Prince and Maughan 1978) by providing locations for resting, refuge, and concealment (Warden and Lorio 1975; Winter 1977) and as stations for feeding and ambushing prey (Warden and Lorio 1975; Prince et al. 1979; Wege and Anderson 1979). Catfish, conversely, are commonly found in deeper, weed-free areas of vegetated ponds. Therefore location of vegetation beds could keep the bass physically separated from the catfish. Such separation in occupied areas could decrease the chance of predation. Separation in areas occupied was seen in Lower Strange Pond. When the pond was rotenoned there was little if any drift of the fish and almost all bass were found in the weeded area of the pond. Conversely the catfish were found in the deeper open water area. Survival of catfish was also high in Lower Strange Pond.

Vegetation also directly affected turbidity (Table XIV). Densely vegetated shorelines are correlated with lower turbidity levels while unvegetated shorelines are correlated with increased turbidity. Turbidity in turn, may have affected catfish survival by affecting predation efficiency. Bass and sunfish feed typically by sight and high turbidity levels may have interfered with feeding. If such an interpretation is correct high turbidity in Quawpa and Airfield Ponds was probably responsible for high catfish survival (Tables VIII and XIV). Conversely low turbidity levels were associated with low catfish survival and may have been the result of increased catfish vulnerablity (Tables VIII and XIV). Turbidity could also have influenced catfish survival by limiting reproduction, growth, and survival (at extremely high levels) of the bass and sunfish (Wallen 1951 and Pflieger 1975). Low survival of predators in Quawpa and Airfield Ponds in 1982 was correlated with high turbidity and high catfish survival (Figure 8;D & E).

Severe water level fluctuations may have positive or negative effects on catfish survival. For example in 1982 Ouray Pond had very low water levels when it was stocked. Bass stomach contents showed heavy predation on catfish (Table XIII). This high predation probably was heightened because the bass and the catfish co-mingling in a pool-like situation devoid of structure. After a major rain event had filled the pond, the bass moved into shallow areas with weed beds and submerged trees. At that time no catfish occurred in stomach contents (Table XIII). Water level fluctuations in Indian Pond apparently had the opposite effect on predation. Low water levels at the time catfish were stocked caused large numbers of sunfish to be forced into open water and gave the bass access to alternative forage (Table XIII). Low numbers of catfish were eaten by predators during this low-water situation (Table XIII). After the rain event catfish became more important in the diet of the bass. This food switch may have occurred because the sunfish were once again within the dense vegetation. Similar patterns occurred in Winnebago Pond (Figure 8;J) (Table VIII). In Lower Strange Pond very constant water levels throughout the summer may have acted to keep the bass and catfish separated and resulted in relatively high survival of catfish (Table VIII).

Growth rates of the catfish also directly affect survival because they affect length of time the catfish are vulnerable to particular predators. As a catfish grows, the number of potential predators decreases. Therefore faster growth enhances survival. Growth rates are directly affected by the number of individuals of other fish species competing for a limited food source. Small channel catfish and sunfish both feed mainly on zooplankton and insects and could potentially compete for food. Our study showed that growth was inversely related to survival of the catfish. This relationship would suggest that food is a limiting factor in some Fort Sill ponds. A manager must decide between stocking a large number of smaller and cheaper catfish which grow slowly and are subjected to predation over a long period of time or stocking a larger catfish that would cost more but initially have fewer predators, grow faster, and soon be free from predation (Tables VII and IX).

CHAPTER VII

MANAGEMENT RECOMMENDATIONS FOR FORT SILL PONDS

Based on my data I would not recommend stocking fry. In ponds without predator populations I would recomend stocking small fingerlings (50-100 mm). In the absence of vertebrate predators (fish) catfish of this size should survive well. Care must be taken not to over stock catfish, as this causes slow growth throughout life. In ponds with established bass populations I would stock fingerlings of least 186 mm total length. It would be possible to stock catfish fingerlings simultaneously with or shortly after young bass and sunfish have been stocked. Care must be taken to ensure that the catfish are large enough to escape predation. Overstocking may be the biggest problem on Fort Sill ponds. The food resources of the ponds on Fort Sill are limited. Desirable growth would more likely occur in understocked ponds than overstocked ponds.

LITERATURE CITED

Adams, S. M., R. B. McLean, and J. A. Parrotta. 1982. Energy partitioning in largemouth bass under conditions of seasonally fluctuating prey availability. Trans. Am. Fish. Soc. 111(5):549-558.

Axon, J. R., L. Hart, and V. Nash. 1979. Recovery of Tagged fish during the Crooked Creek Bay rotenone study at Barkley Lake, Kentucky. Proc. Ann. Conf. S.E. Game and Fish Comm. 33:680-687.

Carlander, K. D. 1969. Handbook of Freshwater Fishery Biology. Iowa State University Press, 3rd ed. 752 pp.

Conover, W. J. 1980. Practical Nonparametric Statistics. John Wiley and Sons. New York, N. Y. 493 pp.

Devaraj, K. V. 1976. On the food of channel catfish stocked in farm ponds. Aquaculture 7:27-32.

Elrod, J. E. 1971. Dynamics of fishes in an Alabama pond subjected to intensive angling. Trans. Am. Fish. Soc. 100(4): 757-768.

Finnell, J. C. and R. M. Jenkins. 1954. Growth of channel catfish in Oklahoma waters: 1954 Revision. Okla. Fish. Res. Lab. Rpt. No. 41, 37 pp.

Gilliland, E. R., C .W Kleinholtz, and M. D. Clady. 1982. The efficiency of removing food items from fish with glass tubes. Annu. Proc. Texas Chap. A.F.S. 4:95-100.

Lawrence, J. M. 1958. Estimated sizes of various forage fishes largemouth bass can swallow. Proc. Ann. Conf. S.E. Game and Fish Comm. 11:220-225.

Lewis, W. M., G. E. Gunning, E. L. Lyles, and W. L. Bridges. 1961. Food choice of largemouth bass as a function of availability and vulnerability of food items. Trans. Am. Fish. Soc. 90: 277-280.

__________, and D. R. Helms. 1964. Vulnerability of forage organisms to largemouth bass. Trans. Am. Fish. Soc. 93: 315-318.

Marzolf, R. C. 1957. The reproduction of channel catfish in Missouri ponds. J. Wildl. Manage. 21(1):22-28.

McGinty, A. S. 1980. Survival, growth and variation in growth of channel catfish fry and fingerlings. Ph.D. Dissertation. Auburn University. Auburn, Alabama. 74 pp.

Mense, J. B. 1978. Fisherman postal survey 1977. Okla. Fish. Res. Lab. Bull. 15. 22 pp.

Moss, D. D. and D. C. Scott. 1961. Dissolved oxygen requirements of three species of fish. Trans. Am. Fish. Soc. 90:377-393.

Pflieger, W. L. 1975. The Fishes of Missouri. Mo. Dep. Conser., Jefferson City. 343 pp.

Prince, E. D. and O. E. Maughan. 1978. Freshwater artificial reefs: biology and economics. Fisheries (Bethesda) 3(1):5-9.

_____________, O. E. Maughan, D. H. Bennett, G. M. Simmons, Jr., J. Stauffer, Jr., and R. J. Strange. 1979. Trophic dynamics associated with a freshwater artifical tire reef. Pages 459-473 in R. H. Stroud and H. Clepper, editors. Predator-prey systems in fisheries management. Sport Fishing Institute, Washington, District of Columbia, USA.

Reynolds, J. B. and D. E. Simpson. 1978. Evaluation of fish sampling methods and rotenone census. Pages 11-24 in G. D. Novinger and J. G. Dillard, eds. New approaches to the management of small impoundments. N. Central Div., Am. Fish. Soc., Spec. Publ. No. 5.

Scott, W. B. and E. J. Crossman. 1973. Freshwater Fishes of Canada. Fish. Res. Board Can., Ottawa. Bull. 184. 966 pp.

Shireman, J. V., D. E. Colle, and R. W. Rottmann. 1978. Size limits to predation on grass carp by largemouth bass. Trans. Am. Fish. Soc. 107(1):213-215.

Snow, H. E. 1971. Harvest and feeding habits of largemouth bass in Murphy Flowage, Wisconsin. Wis. Dep. Nat. Resourc. Res. Tech. Bull. 50. 25 pp.

Summers, G. L. 1980. Food of adult largemouth bass in a small impoundment with dense aquatic vegetation. Proc. Ann. Conf. S.E. Assoc. Fish and Wildl. Agencies 34:130-136.

Tarrant, R. M., Jr. 1960. Choice between two sizes of forage fish by largemouth bass under aquarium conditions. Prog. Fish. Cult. 22(2):83-84.

Tiemeier, O. W. and C. W. Deyoe. 1980. Channel catish: produced in Kansas ponds for profit and pleasure. Kan. Agri. Exp. Stat. Bull. 635.

Timmons, T. J. and O. Pawaputanon. 1980. Relative size relationship in prey selection by largemouth bass in West Point Lake, Alabama-Georgia. Proc. Ann. Conf. S.E. Assoc. Fish and Wildl. Agencies 34:248-252.

Wallen, I. E. 1951. The direct effects of turbidity on fishes. Bull. Okla. Agri. Coll., Arts and Sci. Stud., Bio. Series. 48(2):1-27.

Warden, R. L. and W. J. Lario. 1975. Movements of largemouth bass (Micropterus salmoides) in impounded water as determined by underwater telemetry. Trans. Am. Fish. Soc. 104:696-702.

Wege, G. J. and R. O. Anderson. 1979. Influence of artifical structure on largemouth bass and bluegills in small ponds. Pages 59-69 in D. L. Johnson and R. A. Stein, editors. Response of fish to habitat structure in standing water. North Central Div. Am. Fish. Soc. Spec. Pub. 6.

Winter, J. D. 1977. Summer home range movements and habitat use by four largemouth bass in Mary Lake, Minnesota. Trans. Am. Fish. Soc. 106:323-330.

East Gypsy Pond

East Gypsy Pond is a retangular shaped pond with a surface are of 0.4 hectares and a maximum depth of 3.0 meters. The pond has a dug out basin and is filled by overflow from an adjacent spring fed pond. The pond has steep sides, a homogenious bottom, and little aquatic vegetation (less than 5% of the water surface). The pond has very fine easily dispersed bottom sediments. At the time the fry were stocked the water was relatively clear (Table XIV).

East Gypsy Pond was stocked on June 28, 1982 with 15000 channel catfish fry, of average total length of 13.3 mm. The pond was rotenoned on August 19, 1982 and no catfish were recovered. Intense predation on the channel catfish fry by large sunfish (200-250 mm) and largemouth bass was observed during stocking. A number of large sunfish, 31/hectare (Figure 4) and bass 134/hectare (Figure 5;A) were present in East Gypsy Pond. Very little forage was available for the sunfish and almost no forage was available for the bass (Figure 5;A). It is probable that very few channel catfish survived beyond a few days. The heavy predation was probably the result of water clarity (Table XIV), lack of forage in the pond, the non porous nature of the substrate, and the vulnerability of hatchery reared channel catfish fry.

West Gypsy Pond

West Gypsy Pond is a regular shaped pond which lies adjacent to East Gypsy Pond. The pond also has a dugout basin but is smaller than East Gypsy Pond. The pond covers 0.1 hectares, is 1.44 meters maximum depth, is spring fed, and is typically very clear. West Gypsy Pond was stocked on June 28, 1982 with 5000 channel catfish fry, with an average total length of 13.3 mm. The pond was rotenoned on August 19, 1982 and no channel catfish were recovered. Predation was not observed while stocking channel catfish. A number of large sunfish, 41/hectare (Figure 4) and bass, 345/hectare (Figure 5;B) capable of consuming the catfish fry were present. Available forage was again low (Figure 5;B). The large number of predators coupled with the low mass of forage for bass (Figure 5;B) and sunfish plus absence of cover probably were responsible for the high mortality (Table VIII). Water clarity (Table XIV) and the vulnerability of the fry probably also intensified the predation.

Weed Pond

Weed Pond is a typical Fort Sill and was formed by building an earthen dam across a seasonal waterway. The pond was 0.3 hectares, reaches depths of 4.0 meters along the dam and has heavy vegetation in shallow areas over 25% of the surface area of the pond, <1 meter in depth. The vegetation and relatively stable water levels in Weed Pond kept the water relatively clear during our study but the pond is typically turbid during summer. Weed Pond was stocked with 12000 channel catfish fry on June 28, 1982 average total length 13.3 mm. The pond was rotenoned on August 19, 1982 and no channel catfish were recovered. Many predators, large sunfish 5/hectare (Figure 4) and bass, 454/hectare (Figure 5;C) were present in the pond. The large numbers of predators plus low availability of forage (Figure 5;C) and the high vulnerability of the fry would account for the low survival (Table VIII).

Quawpa Pond

Quawpa Pond is small (0.1 hectare), very shallow (1.75 meters maximum depth), and was formed by damming a seasonal waterway. The small watershed, results in severe water level fluctuations during the course of a year. Water level fluctuations caused the pond to be very turbid. No aquatic vegetation grows in the pond. There was high mortality of the bass and sunfish stocked into Quawpa Pond and water level fluctuations seemed to effectively supress reproduction of forage fish (Figure 8;D).

Quawpa Pond was stocked on August 20, 1982 with 1500 channel catfish with a mean toal length of 74.3 mm. The pond was rotenoned on Septmeber 29, 1982 and 1463 of the catfish were recovered. Ninety seven point five percent of the catfish were recovered even though there were 108 bass of predatory size / hectare present (Figure 8;D), however only 8 bass were actually collected. Lack of predation could result from the availability of alternate forage (small sunfish and golden shiners) (Figure 8;D), plus a very high turbidity level. High turbidity could interfere with predation by the bass (Table XIV), and the low absolute numbers could also have contributed to decreased predatory efficiency (Figure 8;D).

Ouray Pond

Ouray Pond is a moderate size pond of 0.3 hectares with a maximum basin depth of 4.0 meters. Only 5% of the surface area is covered by vegetation but 30% of the pond is shallow, <1.5 meters in depth when the pond is full. At the time of stocking (August 20) the water level in Ouray Pond was down approximately 1.5 meters below normal but on September 15, 1982 a rain event filled the pond. Ouray Pond was stocked with 3000 channel catfish, mean total length of 74.3 mm on August 20, 1982. The pond was rotenoned on September 28, 1982 and 233 or 7.8% of the catfish recovered.

Largemouth bass were collected in Ouray Pond by electroshocking beginning the night after stocking and subsequently approximately once a week until the pond was rotenoned. Bass stomach contents revealed intense predation on the channel catfish beginning immediately after the catfish were stocked. Predation slowed down gradually until the date of the rain event September 16, after which no more catfish were found in the bass diet (Table XIII). Upon rotenoning it was discovered that only 233 or 7.8% of the catfish stocked were still in the pond (Table VIII).

The initial extremely heavy predation is explained by the very large numbers, more than 313 / hectare of available predator bass in the pond (Figure 8;E) and the low amounts of other available forage for these bass (Figure 8;E). Although there was forage in the pond most were too large to be utilized by most of the bass in the pond (Figure 8;E). Another factor which seemed to facilitate predation was the concentration of prey by low water levels. After the rain event most of the bass were found in the shallow backwater area of the pond whereas the catfish were all recovered from the deeper pool area. These observations would suggest that the low water levels increase the contact between bass and catfish.

Indian Pond

Indian Pond, the largest pond used during 1982 was 0.8 hectares in surface area, with a maximum depth of 4.0 meters, and was formed by damming a moderate size seasonal waterway. Turbidity was about average for a Fort Sill pond as was the size of the drainage and the amount of aquatic vegetation (Table XIV). Aquatic vegetation occurred along the shorelines and infested up to 40% of the surface at low water levels. Water levels during the study fluctuated from being 1.0 meter below normal at stocking to 0.2 meters above normal after the large rain event.

Indian Pond was stocked on August 20, 1982 with 8000 channel catfish (average size 74.3 mm in total length). On September 28, 1982 the pond was rotenoned and 4294 or 53.7% of the fish recovered. Indian Pond was electroshocked for bass beginning the night the catfish were stocked and sampled weekly thereafter. Catfish showed up in the diet of the bass beginning the first night they were stocked, but were not as important in the diet as in Ouray Pond (Table XIII). However percent frequency increased throughout the experiment and reached a high of 27.3% the night before the pond was rotenoned. When the pond was rotenoned 53.7% of the catfish that had been stocked were recovered.

The relatively good survival of the channel catfish in Indian Pond is attributable to the large amount of alternate forage present for the bass (Figure 8;F) and the lower density of predators (130/hectare) (Figure 8;F). Not only was there a much greater number of forage present, but this forage was of a size which could be used by most of the bass (Figure 8;F). In addition the low water levels before September 15 forced much of this forage out into open water where it was available to the bass.

Airfield Pond

Airfield Pond is small, 0.26 hectare, with an average depth 3.0 meters, and is typically very turbid (Table XIV). High turbidity results from a lack of aquatic vegetation and recent construction. There is little if any cover provided by debris or irregularities in the substrate. Because of the high turbidity there was relatively low survival of the stocked bass and sunfish. On June 1, 1982 Airfield Pond was stocked with 466 channel catfish (mean total length of 116.8 mm).

The pond was rotenoned on August 18, 1982 and 196 or 42.1% of the catfish were recovered. Very little forage was available for the bass in Airfield Pond at the time of harvest (Figure 8;G) but there were few bass capable of consuming the 116.8 mm channel catfish fingerlings (Figure 8;G). On analysis the situations in Airfield and Quawpa Ponds appeared simular. However in Quawpa Pond the forage was available but not abundant (Figure 8;D) whereas in Airfield the forage was neither available nor abundant (Figure 8;G). In Quawpa Pond the bluegill and goldenshiners appeared to be more susceptible to the bass than the catfish. This differential susceptibility may have something to do with turbidity. However in Airfield which was equally turbid catfish were taken.

Mesquite Pond

Mesquite Pond is small (0.26 hectares), relatively shallow (3.0 meters), and relatively clear (Table XIV). There is very little cover in the pond besides aquatic vegetation. Aquatic vegetation covers the entire shoreline and the shallow backwater area of the pond. About covering about 25% of the surface of the pond is covered when the pond is full. The water level dropped in Mesquite Pond throughout the experiment and the fish were progressivly concentrated. Mesquite Pond was stocked on May 28, 1982 with 466 channel catfish with a mean total length of 120.6 mm. When the pond was rotenoned on August 17, 1982, 111 or 23.8% of the catfish stocked were recovered. Mesquite contained a moderate amount of alternate forage (Figure 8;H). Bass numbers were fairly high with 142 bass/hectare (24 were harvested) theoretically capable of consuming the size catfish stocked (Figure 8;H). The relatively high level of mortality of this larger size of catfish can probably be attributed to the number of bass in the pond, the low numbers of forage available, water clarity, and perhaps vulnerability of hatchery reared catfish.

Lower Strange Pond

Lower Strange Pond is 0.4 hectares in surface area, and was the deepest pond (maximum depth of 6.0 meters) used. Water levels remained constant throughout the study because of leakage from another pond. The constant water levels were accompanied by high water clarity throughout the experiment (Table XIV). The survival of stocked bass was not as high in the pond as in similar ponds. One reason might be high fishing pressure on this particular pond. Lower Strange Pond was stocked on June 1, 1982 with 466 channel catfish which averaged 116.8 mm in total length. When the pond was rotenoned on August 13, 1982, 297 or 63.7% of the catfish stocked were recovered.

There were moderate amounts of forage in the pond at the time of rotenoning (Figure 8;I) and much of this forage was of a size that was available to the existing bass (Figure 8;I). Low numbers of largemouth bass were recovered from Lower Strange. Only 52 bass/hectare that were capable of consuming the size channel catfish stocked were recaptured (Figure 8;I). Bass that were recovered during rotenoning were taken in the shallow weeded area of the pond while the catfish were recovered from the deep basin. Similar results were observed on Ouray Pond but in Ouray Pond low water levels forced the bass into the basin and brought them in contact with the catfish. In Lower Strange Pond the stable water levels appeared to allow the bass and catfish to remain separated. In addition there were large numbers of bullfrog tadpoles in the pond which provided the bass with an alternate forage source. Therefore the high survival of catfish can be attributed to low numbers of bass, suitable alternate forage, and a physical separation of the bass and catfish in the pond.

Winnebago Pond

Winnebago Pond is small (0.13 hectares) and shallow, with a maximum depth of 2.5 meters. Runoff and water level caused the pond to be moderately turbid through out the study. (Table XIV). At full water levels 5% of the surface of the pond was infested with aquatic vegatation. On May 27, 1982 Winnebago Pond was stocked with 60 channel catfish that averaged 158.1 mm in total length. The pond was rotenoned on September 29, 1982 and only 2 catfish or 4% were recovered.

Forage for the bass in Winnebago was very abundant at the time the pond was rotenoned (Figure 8;J). However at the time the catfish were stocked, available forage might have been limiting (Figure 8;J). The number of largemouth bass in Winnebago pond capable of consuming the size catfish that had been stocked was about 99 bass/hectare (Figure 8;J). Since the number of catfish stocked was small even predation by a few bass could easily explain the low survival. Another factor which may or have influenced catfish survival was that two very large catfish (725 mm), were recovered from the pond.

Lower Rabbit Pond

Lower Rabbit Pond is 0.4 hectares in area and has a maximum depth of 3.5 meters. Turbidity was moderately high throughout the study period (Table XIV). The high turbidty resulted from runoff from disturbed land surrounding the pond. At full water levels about 5% of the surface is vegetated but at low water levels 0% is vegetated. On June 3, 1982 Lower Rabbit Pond was stocked on June 3, 1982 with 186 channel catfish fingerlings that averaged 146.4 mm in total length. When the pond was rotenoned on August 11, 1982 15.1% (28) of the catfish were recovered.

There were large amounts of available forage for the very large bass at the time the pond was rotenoned (Figure 8;K). However in the early summer available forage was scarce for the smaller bass capable of consuming the catfish (146.4 mm) stocked (Figure 8;K). Lower Rabbit Pond had large numbers (approximately 120/hectare) of bass which were capable of consuming the size catfish stocked (Figure 8;K). The low survival of catfish can be attributed to these large numbers of bass and the limited available forage in the early summer.

Caddo Pond

Caddo Pond is of moderate size (0.5 hectares) but fairly shallow (maximum depth of 2.0 meters). The pond remained fairly clear throughout the experiment because of small water level fluctuations and extensive shoreline vegetation (Table XIV). Vegetation covers all areas where water depths are <1 meter. This area encompasses 35% of the ponds surface. The pond was stocked with 275 channel catfish (average total length 146.4 mm) on June 3, 1982. When Caddo Pond was rotenoned on August 17, 1982 218 (79.3%) of the catfish were recovered.

Forage was abundant for almost all size clsses of bass (Figure 8;L). The largemouth bass population in the pond was dominated by bass 200-300 mm in total length. Most predatory size bass in the pond were just capable of consuming the size of catfish stocked (Figure 8;L) which probably contributed to the high catfish survival. In addition to few predatory size bass there were large amounts of shallow vegetated areas. The observed moderate decrease in water level forced other forage species into the open water and thereby reduced the pressure on catfish.

VITA 2

Gerald Eugene Mestl

Candidate for the Degree of

Master of Science

Thesis: SURVIVAL OF STOCKED CHANNEL CATFISH IN SMALL PONDS

Major Field: Zoology

Biographical:

Personal Data: Born on August 21, 1958 in Omaha, Nebraska, the son of Eugene and Lavina Mestl.

Education: Graduated from Beemer Public High Scholl, Beemer, Nebraska, May, 1976; received Bachelor of Arts degree from Mount Marty College, Yankton, South Dakota, May 1980; completed requirements for Master of Science degree in Zoology at Oklahoma State University, Stillwater, Oklahoma, May 1983.

Professional Experience: Fishery technician, 1980, Oklahoma Cooperative Fishery Research Unit, Oklahoma State University, Stillwater, Oklahoma; Graduate Research Assistant, 1980-1983, Oklahoma Cooperative Fishery Research Unit, Stillwater, Oklahoma State University, Stillwater, Oklahoma.

Professional Affiliations: National and Oklahoma Chapter of the American Fisheries Society.