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An Assessment of Lake Chubsuckers (*Erimyzon sucetta* (Girard)) as Forage for Largemouth Bass (*Micropterus salmoides* (Lacepede)) In A Small Nebraska Pond

Randle A. Winter

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(Erimyzon sucetta (Girard)*)*

As Forage For

Largemouth Bass
(Micropterus salmoides (Lacepede)*)*

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Nebraska Technical Series No. 16

NEBRASKA GAME AND PARKS COMMISSION
Eugene T. Mahoney, Director

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ABSTRACT

Lake chubsuckers (*Erimyzon sucetta* (Girard)) were introduced into two ponds to examine their suitability as a sustainable forage for largemouth bass (*Micropterus salmoides* (Lacepede)). A summary of lake chubsucker suitability followed the criteria of Bennett and Childers (1966).

Lake chubsuckers were capable of growing larger than the size range for predation by most largemouth bass, however, their growth rate made them vulnerable to largemouth bass for several years. Young of the lake chubsuckers were not available as forage for age 0 largemouth bass. Even though lake chubsuckers possess round bodies and soft rayed fins, this was not demonstrated to be a superior attribute. Lake chubsuckers were not able to maintain a viable population of adults in combination with dominant largemouth bass. Lake chubsucker diets revealed neither predation on largemouth bass eggs or fry nor competition with various sized largemouth bass for food. Mean annual measures of selected physical, chemical and biological characteristics of the fish habitat indicated significant changes in total alkalinity, Secchi disk transparency and surface coverage by rooted aquatic macrophytes. It was concluded lake chubsuckers were not directly responsible for these changes. In this study lake chubsuckers did not significantly improve largemouth bass growth.

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INTRODUCTION

Morris (1977) estimated that 29% of all fishing in Nebraska occurs on private lakes and ponds. Nebraska contains about 40,000 private ponds suitable for fisheries (pers. comm. Bob Koerner, Soil Conservation Service Biologist, U.S. Department of Agriculture). Standard stocking strategy for these waters include largemouth bass (*Micropterus salmoides* (Lacepede)) and bluegill (*Lepomis macrochirus* (Rafinesque)). Frequently, overharvest of largemouth bass, in spite of appropriate size limits, leads to a fish community dominated by stunted bluegills. A contributing factor is the lack of interest in bluegill fishing by a large number of pond fishermen. Efforts to educate pondowners and the fishing public to the importance of good management practices such as limited largemouth bass harvest and adequate bluegill harvest, have had limited success. A potential consequence of mismanagement of the fishery by the pondowner is reduced fishing opportunities. This may result in a shift of fishing pressure to already overexploited public waters and/or reduced fishing license revenue. One remedy could be to consider alternative forage species that may provide long lasting, stable, and productive largemouth bass fisheries in small private ponds.

The lake chubsucker *(Erimyzon sucetta* (Girard)), a member of the family Catostomidae, may provide this alternative. This fish is not native to Nebraska. Its native range includes ponds and lakes throughout the eastern United States, from eastern Minnesota to New England south to Florida and Texas (Eddy and Underhill 1980). This species is usually considered to consist of two subspecies, (*E. s. sucetta),* coastwise east of the Allegheny Mountains, and (*E.s. kennerlyi),* around the Great Lakes and west of the Alleghenys (Hubbs 1930).

The objective of this study was to examine the potential suitability of the lake chubsucker as forage for largemouth bass in small man-made impoundments in Nebraska.

STUDY SITES

Research was conducted on two small flood control reservoirs, sites 054 (Figure 1) and 059 (Figure 2) located in the Big Nemaha River drainage on the Nebraska Game and Parks' 457 hectare Pawnee Prairie Wildlife Management Area, Pawnee County, Nebraska. The watersheds of both ponds are totally vegetated with native prairie grasses interspersed with deciduous woody plants. Dominant soil types are Shelby clay loam, Pawnee loam and Burchard clay loam (Sautter 1976). Each pond bottom contains a mixture of those soil types and decaying organic matter. Pond Site 054 is a 0.7 hectare, 16 year old pond with a maximum depth of 3.75 m at conservation pool. It has a shoreline development index of 2.39 and a drainage area to volume ratio of 19:1. Overflow from a 0.1 hectare pond, incapable of supporting a fishery, empties into Site 054. Site 059 is a 0.2 hectare, 6 year old pond with a maximum depth of 3.2 m at conservation pool. It has a shoreline development index of 2.63 and a drainage area to volume ratio of 26:1.

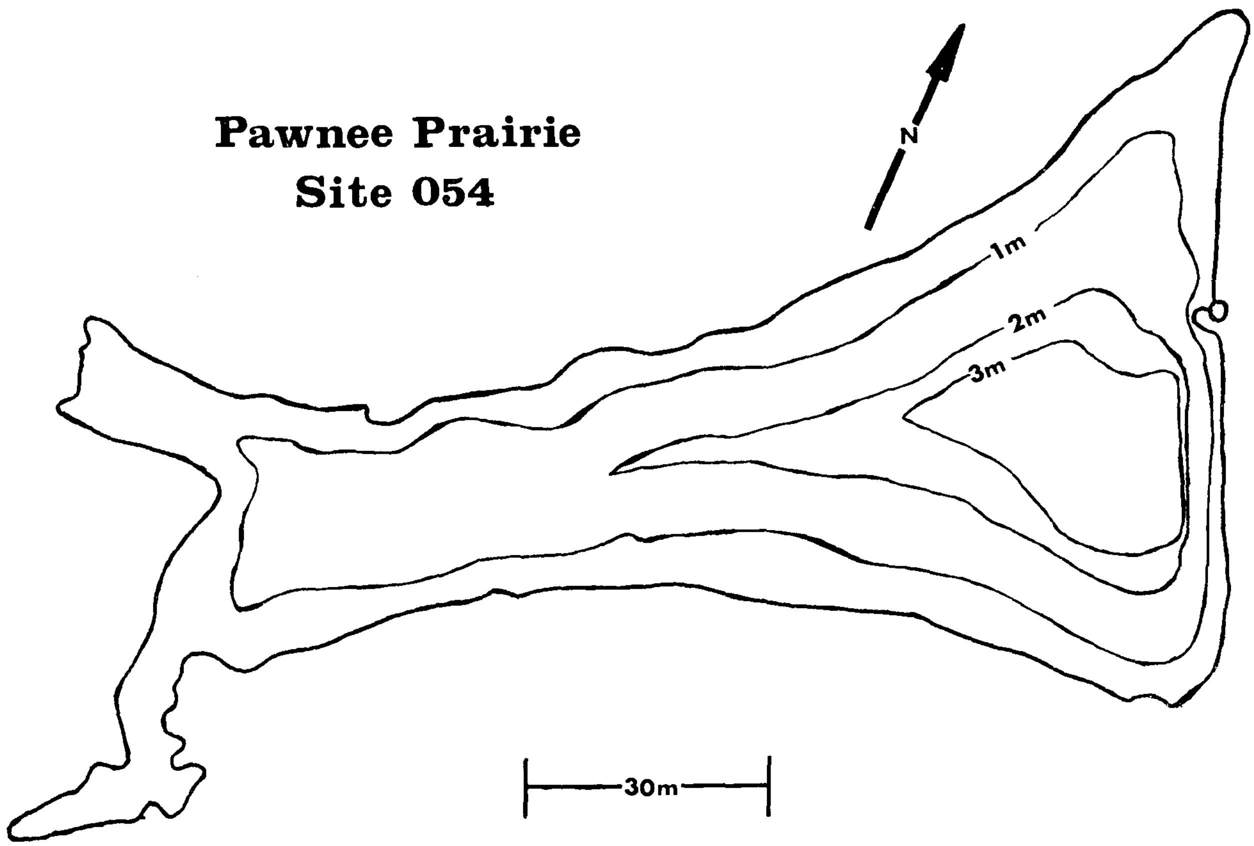

Figure 1. Contour map of Pawnee Prairie Site 054.

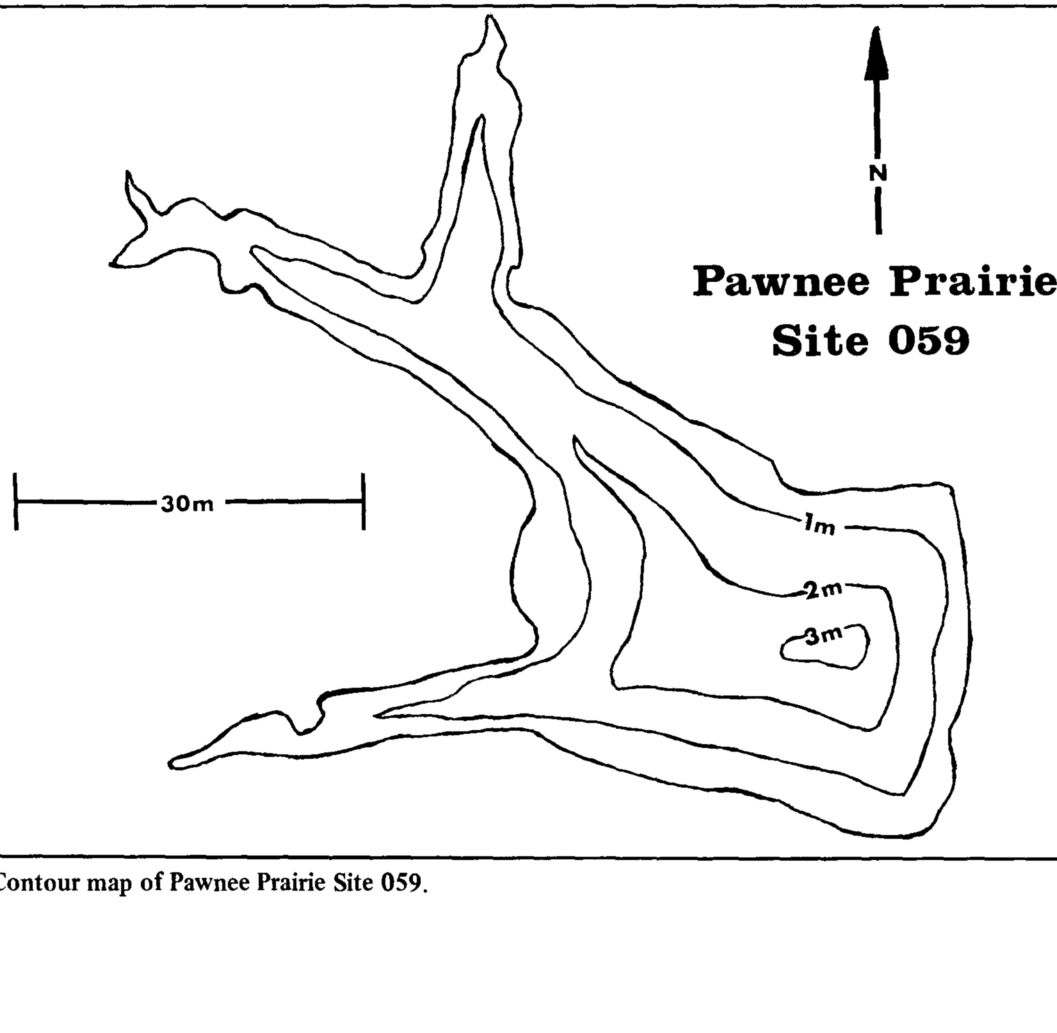

Figure 2. Contour map of Pawnee Prairie Site 059.

METHODS AND MATERIALS

Initial Stocking

Both research ponds were treated with rotenone on 9 September 1978 to remove all fish. Fathead minnows (*Pimephales promelas* (Rafinesque)) and age 0 largemouth bass were observed in Site 059 during the renovation. Fish were not observed during the Site 054 renovation, however during the 1980 and 1981 sample periods 31 and 12 northern pike (*Esox lucius* (Linnaeus)) respectively, were captured. It is not known how or when they gained entry to the pond.

On 13 October 1978, 270 lake chubsuckers (ages 0-4) were stocked in Site 054 and on 19 October 1978, 181 age 0 largemouth bass were stocked. Pond Site 059 was not stocked with largemouth bass, however, 114 lake chubsuckers (ages 0-4) were stocked on 13 October 1978.

Lake chubsuckers used in this research were obtained from the Indiana Dept. of Natural Resources and identified as (*E.S. kennerlyi*).

Collecting and Sampling Procedures

Data collection began 1 January 1979 and continued through 31 December 1981. All fish were collected by electrofishing or hook and line. Electrofishing gear consisted of a small johnboat equipped with a variable pulsator regulating current from a 230 - volt, 3000 - watt AC generator. Fish were netted and placed in a live well in the boat. Prior to additional handling, fish were anesthetized with 25 mg/liter quinaldine sulfate solution. Each fish was routinely weighed to the nearest gram (g) and measured to the nearest millimeter (mm) total length. Post handling procedures for Site 054 fish consisted of placing age 0 largemouth bass and all lake chubsuckers in a mesh net suspended in the water. This allowed the fish to recover from the anesthetic before release, preventing increased vulnerability to predation, a potential confounding effect. Anesthetized age 1 and older largemouth bass were considered safe from predation due to their large size. All northern pike were removed from Site 054 after collecting appropriate data. Post handling procedures for Site 059 lake chubsuckers are addressed in the methods Reproduction Section.

Age and Growth

Age and growth of lake chubsuckers northern pike and largemouth bass were determined from scales and corresponding length measurements. Lake chubsucker age and growth data were collected in October and November of 1979, 1980 and 1981, largemouth bass age and growth data in October and November of 1980 and 1981, and northern pike age and growth data in October and November of 1980.

Largemouth bass and northern pike scales were taken in the region of the tip of the pectoral fin below the lateral line on the fish's left side, while the lake chubsucker's scales were removed from the area between the origin of the dorsal fin and the lateral line on the fish's left side.

In the laboratory, scales were impressed on acetate slides. Each scale was projected under an Eberbach scale microprojector or a Micron 780 microfiche reader. Projected scale images were measured from their focus to each annulus and the outer margin. Calculations were executed using a modification of the direct proportion formula (Fraser 1916):

$$Ln\text{-}a = \frac{Sn}{S}(L\text{-}a)$$

where Ln = length of fish when annulus 'n' was formed, L = length of fish when the scale sample was obtained, Sn = radius of annulus 'n', S = total scale radius and a is a constant developed from the intercept of the regression line on the length axis.

Length-weight relationships were calculated using the equation (Ricker 1975):

$$w = aL^b$$

where L = total length of fish, w = weight of fish at length L, a and b are constants derived empirically from the data.

Condition factors (KTL) were calculated from:

$$KTL = \frac{10^5\ w}{L^3}$$

where w and L are the observed total weight and total length of a fish.

Relative weight (W_r), another index of condition comparing actual weight (W) of a fish with a standard weight (W_S), was used on largemouth bass (Wege and Anderson 1978). Length-weight data for largemouth bass collected in 18 midwestern ponds were used to evaluate W_r. The index is determined by the formula:

$$W_r = \frac{W}{W_s}(100)$$

Proportional stock density (PSD), the percentage of stock-size bass (200 mm and greater) that are quality size (305 mm and greater), was also routinely calculated (Reynolds and Babb 1978).

Reproduction

Lake chubsucker reproductive characteristics were examined using fish collected by boat electrofishing from Site 059. Peabody Ryan 90 day thermometers continuously recorded water temperatures in each site throughout the spawning season.

Spawning Season

Time and duration of the lake chubsucker's spawning season was determined from abrupt drops in mature female gonadosomatic indices (GSI), coincident with the percentage of spent females, in weekly samples. A GSI is defined as the weight of the gonads as a percentage of the total weight of the fish. Gonadal changes were correlated with water temperatures by the use of the recording thermometer.

Fish to be sacrificed were randomly selected from the pool of captured specimens, dissected and examined internally until at least 10 mature females were obtained.

Female lake chubsuckers were classified as immature when ova development was not evident. Mature females included specimens with developing ova, fish that were ready to spawn and spent fish. All mature females were preserved in 10% formalin and returned to the laboratory for further examination.

In the laboratory, each fish was weighed intact, after which the gonads were removed and weighed to the nearest mg.

Fecundity

Excised ovaries from mature female lake chubsuckers were used for fecundity determinations. Fecundity estimate procedures followed those described by Bagenal and Braum (1978) using the wet method of gravimetric subsampling. Absolute fecundity was regressed against both total length and total weight of the fish.

Population and Biomass Estimates

Lake chubsucker and largemouth bass biomass were calculated using population estimates by year class, each class estimate then multiplied by its individuals calculated mean weight. The modified Schnabel (Ricker 1975) population estimate technique was used in Site 054 during October and November of 1980 and 1981. Electroshocked fish were handled by previously described procedures, concluded by marking with a lower caudal fin clip in 1980, an upper caudal fin clip in 1981, and when appropriate, placed in the recovery net until they were capable of swimming off. This allowed detection and adjustment for mortality of marked fish. Sampling began in October and continued weekly, unless weather dictated otherwise, until the pond surface froze. One unit of effort consisted of one pass around the lake while attempting to net all fish. This effort was employed on each occasion.

Food Habits

Largemouth bass and northern pike used for food habits analysis were either collected by boat electrofishing or hook and line, while lake chubsuckers were only collected by boat electrofishing. Each fish captured was promptly anesthetized, measured, weighed and scales were removed for aging. Stomach samples were taken during the 1979, 1980 and 1981 seasons for largemouth bass and lake chubsuckers but only during the 1980 season for northern pike. Food habits are presented for each 50 mm size group of fish. However, all sizes of fish were not sampled annually, consequently some years are not presented in the food habits tables for a given size of fish.

To minimize disruption of largemouth bass production, stomach contents were removed by pulsed gastric lavage, (Foster 1977) a stomach flushing technique which does not require sacrificing the fish. Each fish stomach was flushed for three successive 10-15 second intervals, reducing mean total handling time per fish to 75 seconds. Stomach contents were flushed into a funnel fitted with a threaded plastic cap and bottle. The bottle's bottom was recovered with 243 μ Nitex netting. Stomach contents were then collected free of excess water, rinsed into a jar of 10% formaldehyde containing an identification label, and returned to the laboratory.

Lake chubsuckers and northern pike were sacrificed in the field, the coelom incised, each individual placed in a jar of 10% formaldehyde with an identification label and returned to the laboratory.

Formaldehyde fixation continued until all tissues were rigid. Prior to examination all stomach contents were transferred to 70% ethanol.

Immediately prior to examination each lake chubsucker or northern pike stomach was removed, opened and contents rinsed into a petri dish. Hemostatic forceps were placed on each stomach opening, preventing loss of contents during removal.

Each stomach's contents were inspected under a binocular dissecting microscope. Food items were identified to the lowest practical taxonomic group, counted and weighed. Inclusion and enumeration of partial food organisms were determined by the presence of a resistant taxonomically identifiable structure. Identification of organisms was facilitated by using the keys of Usinger (1971), Merritt and Cummins (1978), Pennak (1978) and Borror et al. (1976).

Most food items were individually counted, however, due to their large numbers, zooplankton and occasionally dipterans were estimated by subsampling.

Gravimetric analysis was conducted using reconstructed dry weights of organisms. Many organisms identified in fish stomachs were collected live from the pond sites, thus facilitating both identification and weight analysis.

Other organisms had to be represented by their best preserved specimens from fish stomach samples. Weights of consumed fish were reconstructed from length-dry weight regressions of live captured fish using dimensions of distinguishable body structures. Drying was done at a temperature of 105 C until a constant weight was achieved. Weighing was done with an analytical balance to 0.01 mg.

Food habits were evaluated by frequency of occurrence, percent composition by number and percent composition by dry weight. Empty stomachs were excluded from these calculations.

Physiochemical Pond Characteristics

Several physical, chemical and biological characteristics of Site 054 were monitored. Sampling was conducted monthly from May through October in 1979, 1980 and 1981.

Temperature and dissolved oxygen profiles were developed from the surface and at 0.5 m increments thereafter using an electronic meter; total alkalinity, total hardness and pH were measured at the surface using a Hach kit; Secchi disk depths were measured to the nearest centimeter; and surface coverage and species composition of aquatic vegetation were estimated.

A one-way classification analysis of variance (ANOVA) was used to determine if total alkalinity, total hardness, pH and Secchi disk transparency mean values changed significantly (at 5 and 1% levels) from season to season over the study period. Significant changes were tested using Tukey's w-procedure (Steel and Torrie 1960) to identify those seasons between which they occurred. This information was then interpreted in light of changes in the lake chubsucker population in order to identify a cause and effect relationship.

RESULTS

AGE AND GROWTH

Largemouth Bass

Length frequency-age distribution analysis of largemouth bass was based on 366 and 139 fish in 1980 and 1981, respectively (Table 1). Age and growth analysis were based on 60 and 139 fish, respectively (Table 2). Length-weight regression and length-scale radius equations for 1980 and 1981 appear in Table 2. In the length-scale radius equations, the constant a was assigned a value of 30 mm. This value was based on an extensive examination of length-scale radius data by the Nebraska Game and Parks Fisheries Division and is presently being used as a standard for largemouth bass age and growth analysis.

Proportional stock densities (PSD) and mean relative weights (W_r) of the entire population of largemouth bass for 1980 and 1981 are presented in Table 3.

Lake Chubsuckers

Length frequency-age distribution analysis of lake chubsuckers in Site 054 was based on 247 fish in 1979, 1,281 fish in 1980 and 36 fish in 1981 (Table 4); age and growth analysis was based on 125, 200 and 35 fish, respectively (Table 5). Length-weight regressions and length-scale radius equations for 1979, 1980 and 1981 appear in Table 5. In the length-scale radius equations, the constant a was assigned a value of zero based on actual calculations providing y-intercept values of 2.701, -1.173 and -1.003 for 1979, 1980 and 1981 respectively. Using the constant allows for more realistic age and growth comparisons between different samples of the same population over time.

Length frequency-age distribution analysis of lake chubsuckers in Site 059 during 1981 was based on 105 fish (Table 6) while age and growth analysis was based on 98 fish (Table 7). The length-weight regression and length-scale radius equations appear in Table 7. In the length-scale radius equation, the constant a was again assigned a value of zero.

Northern Pike

Length frequency-age distribution analysis of northern pike was based on 31 fish in 1980 (Table 8), while age and growth analysis was based on 29 fish (Table 9). Length-weight regression and length-scale radius equations appear in Table 9. In the length-scale radius equation the constant a was assigned a value of 30 mm. This value is presently being used as a standard for northern pike age and growth analysis by the Nebraska Game and Parks' Fisheries Division.

1980

Length Interval (mm)	Number of Fish	Percent of Total	Weight (g)	Percent of Total	Mean Weight (g)	Mean KTL	Mean Wr	Age Group 0	1	2	3	4
50- 74	76	20.8	340	1.4	4.5	1.20	1.10	76	0	0	0	0
75- 99	231	63.1	1643	7.6	7.1	1.29	1.16	231	0	0	0	0
100-124	4	1.1	46	0.4	11.7	1.10	0.95	4	0	0	0	0
125-149	1	0.3	0	0.0	0.0	0.00	0.00	0	0	0	0	0
150-174	0	0.0	0	0.0	0.0	0.00	0.00	0	0	0	0	0
175-199	0	0.0	0	0.0	0.0	0.00	0.00	0	0	0	0	0
200-224	0	0.0	0	0.0	0.0	0.00	0.00	0	0	0	0	0
225-249	0	0.0	0	0.0	0.0	0.00	0.00	0	0	0	0	0
250-274	0	0.0	0	0.0	0.0	0.00	0.00	0	0	0	0	0
275-299	9	2.5	3343	9.1	371.5	1.42	1.00	0	0	9	0	0
300-324	30	8.2	13481	54.9	449.4	1.45	1.01	0	0	30	0	0
325-349	15	4.1	8163	26.6	544.2	1.46	1.00	0	0	15	0	0
350-374	0	0.0	0	0.0	0.0	0.00	0.00	0	0	0	0	0
TOTAL	366		27016		Number By Age Class			311	0	54	0	0
					% By Age Class			85	0	15	0	0
					Standard Error % By Age Class			2	0	2	0	0

Total Aged Fish 60 (16.4%)
Total Unaged Fish 306 (83.6%)

Table 1a. Largemouth bass length frequency-age distribution analysis in Site 054 for 1980.

1981 Length Interval (mm)	Number of Fish	Percent of Total	Weight (g)	Percent of Total	Mean Weight (g)	Mean KTL	Mean Wr	Age Group 0	1	2	3	4
50- 74	20	14.4	67	0.2	3.4	1.08	1.01	20	0	0	0	0
75- 99	21	15.1	152	0.6	7.3	1.04	0.92	21	0	0	0	0
100-124	13	9.4	173	0.6	13.4	1.05	0.90	13	0	0	0	0
125-149	1	0.7	45	0.2	45.0	1.48	1.19	0	1	0	0	0
150-174	7	5.0	401	1.5	57.4	1.31	1.03	0	7	0	0	0
175-199	20	14.4	1698	6.2	84.9	1.31	1.00	0	20	0	0	0
200-224	9	6.5	1091	4.0	121.3	1.29	0.97	0	9	0	0	0
225-249	0	0.0	0	0.0	0.0	0.00	0.00	0	0	0	0	0
250-274	0	0.0	0	0.0	0.0	0.00	0.00	0	0	0	0	0
275-299	0	0.0	0	0.0	0.0	0.00	0.00	0	0	0	0	0
300-324	25	18.0	11083	40.7	443.4	1.41	0.98	0	0	0	25	0
325-349	21	15.1	11201	41.1	533.4	1.41	0.97	0	0	0	21	0
350-374	2	1.4	1304	4.8	652.0	1.41	0.96	0	0	0	2	0
TOTAL	139		27215		Number By Age Class			54	37	0	48	0
					% By Age Class			39	27	0	35	0
					Standard Error % By Age Class			4	4	0	4	0

Total Aged Fish 139 (100.0%)
Total Unaged Fish 0 (0.0%)

Table 1b. Largemouth bass length frequency-age distribution analysis in Site 054 for 1981.

1980 Year Class	Aged Fish	Length Range (mm)	At Capture Mean Length (mm)	Mean Weight (g)	Mean KTL	Mean Wr	Age Backcalculated Lengths (mm) With Standard Error and Increments 1	2	3	4	5
1980	47	70-103	82	7	1.22	1.10					
1979	0	0- 0	0	0	0.00	0.00	0				
							0.0				
1978	13	296-343	319	480	1.47	1.02	145	289			
							8.4				
								144			
Total	60	Weighted Mean Length At Annulus (mm)					145	289			
		SE Mean Length (mm)					8.4	5.9			
		Mean Length Increment (mm)						144			
		Minimum Backcalculated Length (mm)					76	251			
		Maximum Backcalculated Length (mm)					183	323			
		Sample Size (n)					13	13			
		Calculated Mean Weight (g)					40	346			
		Mean Weight Increment (g)						306			

The calculated weight-length regression is $W = 7.6435 \times 10^{-6} L^{3.1104}$, ($r = 0.9906$, $P[H_0: r = 0] < 0.05$).
The calculated length-scale radius equation is $Ln = 14.8947 + 1.4676 (Sn)$ where a = 30mm, ($r = 0.9951$, $P[H_0: r = 0] < 0.05$).

Table 2a. Largemouth bass age and growth analysis in Site 054 during 1980.

1981

Year Class	Aged Fish	Length Range (mm)	At Capture Mean Length (mm)	Mean Weight (g)	Mean KTL	Mean Wr	1		Age Backcalculated Lengths (mm) With Standard Error and Increments 2		3	4	5
1981	54	55-117	85	7	1.06	0.95							
1980	37	145-221	187	88	1.31	1.01	82						
							2.3						
1979	0	0- 0	0	0	0.00	0.00	0		0				
							0.0						
								0					
1978	48	302-362	326	491	1.41	0.97	120		199		295		
							3.6		5.0				
								79		96			
Total	139	Weighted Mean Length At Annulus (mm)					103		199		295		
		SE Mean Length (mm)					3.0		5.0		4.0		
		Mean Length Increment (mm)						96		96			
		Minimum Backcalculated Length (mm)					63		136		208		
		Maximum Backcalculated Length (mm)					174		280		351		
		Sample Size (n)					85		48		48		
		Calculated Mean Weight (g)					12		100		355		
		Mean Weight Increment (g)						88		255			

The calculated weight-length regression is $W = 4.4246 \times 10^{-6} L^{3.2005}$, ($r = 0.9990$, $P\ [H_0: r = 0] < 0.05$).
The calculated length-scale radius equation is $Ln = 16.5201 + 1.2698\ (Sn)$ where $a = 30$mm, ($r = 0.9641$, $P\ [H_0: r = 0] < 0.05$).

Table 2b. Largemouth bass age and growth analysis in Site 054 during 1981.

Year Class	Proportional Stock Density-PSD (95% CI)	Mean Relative Weight - W_r
1980	83.3% (73.4-93.3)	1.125
1981	84.2% (74.7-93.7)	0.971

Table 3. Proportional stock densities and weight relations of largemouth bass from Site 054 during 1980 and 1981.

1979 Length Interval (mm)	Number of Fish	Percent of Total	Weight (g)	Percent of Total	Mean Weight (g)	Mean KTL	Mean Wr	Age Group 0	1	2	3	4
50- 74	33	13.4	101	1.7	3.1	1.00	0.00	33	0	0	0	0
75- 99	41	16.6	409	6.9	10.0	1.21	0.00	41	0	0	0	0
100-124	135	54.7	1992	33.7	14.8	1.19	0.00	130	5	0	0	0
125-149	10	4.0	340	5.7	34.0	1.35	0.00	1	8	1	0	0
150-174	6	2.4	329	5.6	54.8	1.35	0.00	0	4	2	0	0
175-199	12	4.9	1050	17.7	87.5	1.32	0.00	0	3	9	0	0
200-224	3	1.2	400	6.8	133.3	1.28	0.00	0	0	1	2	0
225-249	6	2.4	1063	18.0	177.2	1.32	0.00	0	0	1	5	0
250-274	1	0.4	235	4.0	235.0	1.37	0.00	0	0	0	0	1
TOTAL	247		5919		Number By Age Class			205	20	14	7	1
					% By Age Class			83	8	6	3	0
					Standard Error % By Age Class			2	2	1	1	0
								Total Aged Fish 125 (50.6%)				
								Total Unaged Fish 122 (49.4%)				

Table 4a. Lake chubsucker length frequency-age distribution analysis in Site 054 for 1979.

1980 Length Interval (mm)	Number of Fish	Percent of Total	Weight (g)	Percent of Total	Mean Weight (g)	Mean KTL	Mean Wr	Age Group 0	1	2	3	4
20- 29	0	0.0	0	0.0	0.0	0.00	0.00	0	0	0	0	0
30- 39	0	0.0	0	0.0	0.0	0.00	0.00	0	0	0	0	0
40- 49	0	0.0	0	0.0	0.0	0.00	0.00	0	0	0	0	0
50- 59	11	0.9	16	0.1	1.5	0.76	0.00	11	0	0	0	0
60- 69	194	15.1	621	2.1	3.2	1.07	0.00	194	0	0	0	0
70- 79	314	24.5	1397	6.0	4.5	1.12	0.00	314	0	0	0	0
80- 89	167	13.0	1259	5.0	7.5	1.23	0.00	46	121	0	0	0
90- 99	198	15.5	1922	11.5	9.7	1.17	0.00	0	198	0	0	0
100-109	165	12.9	2444	12.5	14.8	1.27	0.00	0	165	0	0	0
110-119	94	7.3	1680	11.3	17.9	1.20	0.00	0	94	0	0	0
120-129	65	5.1	1489	11.4	22.9	1.20	0.00	0	65	0	0	0
130-139	23	1.8	661	6.6	28.8	1.20	0.00	0	23	0	0	0
140-149	24	1.9	900	7.2	37.5	1.25	0.00	0	24	0	0	0
150-159	9	0.7	412	5.3	45.8	1.27	0.00	0	9	0	0	0
160-169	3	0.2	165	1.1	55.0	1.27	0.00	0	0	3	0	0
170-179	0	0.0	0	0.0	0.0	0.00	0.00	0	0	0	0	0
180-189	0	0.0	0	0.0	0.0	0.00	0.00	0	0	0	0	0
190-199	0	0.0	0	0.0	0.0	0.00	0.00	0	0	0	0	0
200-209	0	0.0	0	0.0	0.0	0.00	0.00	0	0	0	0	0
210-219	1	0.1	153	2.9	153.0	1.54	0.00	0	0	0	0	0
220-229	6	0.5	1008	9.6	168.0	1.46	0.00	0	0	6	0	0
230-239	2	0.2	376	3.6	188.0	1.45	0.00	0	0	0	0	0
240-249	4	0.3	824	3.9	206.0	1.49	0.00	0	0	0	0	0
250-259	1	0.1	0	0.0	0.0	0.00	0.00	0	0	0	0	0
TOTAL	1281		15327		Number By Age Class			565	699	9	0	0
					% By Age Class			44	55	1	0	0
					Standard Error % By Age Class			1	1	0	0	0
								Total Aged Fish 200 (15.6%)				
								Total Unaged Fish 1081 (84.4%)				

Table 4b. Lake chubsucker length frequency-age distribution analysis in Site 054 for 1980.

1981 Length Interval (mm)	Number of Fish	Percent of Total	Weight (g)	Percent of Total	Mean Weight (g)	Mean KTL	Mean Wr	Age Group 0	1	2	3	4
20- 29	0	0.0	0	0.0	0.0	0.00	0.00	0	0	0	0	0
30- 39	0	0.0	0	0.0	0.0	0.00	0.00	0	0	0	0	0
40- 49	0	0.0	0	0.0	0.0	0.00	0.00	0	0	0	0	0
50- 59	0	0.0	0	0.0	0.0	0.00	0.00	0	0	0	0	0
60- 69	0	0.0	0	0.0	0.0	0.00	0.00	0	0	0	0	0
70- 79	0	0.0	0	0.0	0.0	0.00	0.00	0	0	0	0	0
80- 89	0	0.0	0	0.0	0.0	0.00	0.00	0	0	0	0	0
90- 99	7	19.4	71	2.6	10.3	1.12	0.00	0	7	0	0	0
199-109	8	22.2	94	3.4	11.8	1.04	0.00	0	8	0	0	0
110-119	6	16.7	105	3.9	17.5	1.16	0.00	0	6	0	0	0
120-129	6	16.7	126	4.7	21.2	1.13	0.00	0	3	3	0	0
130-139	1	2.8	27	1.0	27.0	1.20	0.00	0	1	0	0	0
140-149	0	0.0	0	0.0	0.0	0.00	0.00	0	0	0	0	0
150-159	0	0.0	0	0.0	0.0	0.00	0.00	0	0	0	0	0
160-169	1	2.8	54	2.0	54.0	1.14	0.00	0	0	0	1	0
170-179	0	0.0	0	0.0	0.0	0.00	0.00	0	0	0	0	0
180-189	0	0.0	0	0.0	0.0	0.00	0.00	0	0	0	0	0
190-199	0	0.0	0	0.0	0.0	0.00	0.00	0	0	0	0	0
200-209	0	0.0	0	0.0	0.0	0.00	0.00	0	0	0	0	0
210-219	0	0.0	0	0.0	0.0	0.00	0.00	0	0	0	0	0
220-229	0	0.0	0	0.0	0.0	0.00	0.00	0	0	0	0	0
230-239	0	0.0	0	0.0	0.0	0.00	0.00	0	0	0	0	0
240-249	0	0.0	0	0.0	0.0	0.00	0.00	0	0	0	0	0
250-259	1	2.8	270	9.9	270.0	1.69	0.00	0	0	0	0	0
260-269	2	5.6	573	21.0	286.5	1.60	0.00	0	0	0	2	0
270-279	3	8.3	984	36.1	328.0	1.61	0.00	0	0	0	3	0
280-289	0	0.0	0	0.0	0.0	0.00	0.00	0	0	0	0	0
290-299	1	2.8	420	15.4	420.0	1.64	0.00	0	0	0	0	1
TOTAL	36		2724		Number By Age Class			0	25	3	7	1
					% By Age Class			0	69	8	19	3
					Standard Error % By Age Class			0	8	5	7	3
								Total Aged Fish 35 (97.2%)				
								Total Unaged Fish 1 (2.8%)				

Table 4c. Lake chubsucker length frequency-age distribution analysis in Site 054 for 1981.

1979

Year Class	Aged Fish	Length Range (mm)	At Capture Mean Length (mm)	At Capture Mean Weight (g)	Mean KTL	Mean Wr	Age Backcalculated Lengths (mm) With Standard Error and Increments 1		2		3		4		5
1979	87	61-128	97	12	1.21	0.00									
1978	17	115-197	148	48	1.33	0.00	78								
							3.2								
1977	13	136-234	184	86	1.32	0.00	55		137						
							4.4		6.1						
								82							
1976	7	221-248	233	165	1.30	0.00	73		166		213				
							2.6		4.7		7.3				
								93		47					
1975	1	258-258	258	235	1.37	0.00	55		105		147		248		
							0.0		0.0		0.0		0.0		
								50		42		101			
TOTAL125		Weighted Mean Length At Annulus (mm)					69		145		204		248		
		SE Mean Length (mm)					2.6		6.0		9.0		0.0		
		Mean Length Increment (mm)						76		59		44			
		Minimum Backcalculated Length (mm)					40		96		147		248		
		Maximum Backcalculated Length (mm)					112		196		227		248		
		Sample Size (n)					38		21		8		1		
		Calculated Mean Weight (g)					8		40		124		235		
		Mean Weight Increment (g)						37		84		111			

The calculated weight-length regression is $W = 2.6012 \times 10^{-6} L^{3.3210}$, ($r = 0.9778$, $P[H_0{:}r = 0] < 0.05$).
The calculated length-scale radius equation is $Ln = 14.5566 + 1.2011 (Sn)$ where $a = 0$, ($r = 0.9621$, $P[H_0{:}r = 0] < 0.05$).

Table 5a. Lake Chubsucker age and growth analysis in Site 054 for 1979.

1980

Year Class	Aged Fish	Length Range (mm)	At Capture Mean Length (mm)	At Capture Mean Weight (g)	Mean KTL	Mean Wr	Age Backcalculated Lengths (mm) With Standard Error and Increments 1		2		3		4		5
1980	54	57- 84	71	3	0.78	0.00									
1979	143	80-158	110	14	0.95	0.00	59								
							1.1								
1978	3	166-225	205	110	0.97	0.00	86		174						
							11.1								
								88							
Total	200	Weighted Mean Length At Annulus (mm)					59		174						
		SE Mean Length (mm)					1.2		11.6						
		Mean Length Increment (mm)						115							
		Minimum Backcalculated Length (mm)					35		153						
		Maximum Backcalculated Length (mm)					103		192						
		Sample Size (n)					146		3						
		Calculated Mean Weight (g)					2		70						
		Mean Weight Increment (g)						68							

The calculated weight-length regression is $W = 3.7475 \times 10^{-6} L^{3.2458}$, ($r = 0.9635$, $P[H_0{:} r = 0] < 0.05$).
The calculated length-scale radius equation is $Ln = 20.8988 + 0.9207 (Sn)$ where $a = 0$, ($r = 0.9409$, $P[H_0{:} r = 0] < 0.05$).

Table 5b. Lake Chubsucker age and growth analysis in Site 054 for 1980.

1981

Year Class	Aged Fish	Length Range (mm)	At Capture Mean Length (mm)	At Capture Mean Weight (g)	Mean KTL	Mean Wr	1		2		3		4		5
							Age Backcalculated Lengths (mm) With Standard Error and Increments								
1981	0	0- 0	0	0	0.00	0.00									
1980	25	95-131	108	15	1.12	0.00	58								
							1.3								
1979	3	122-126	124	20	1.07	0.00	65		104						
							2.1								
								39							
1978	6	168-275	248	258	1.54	0.00	77		183		230				
							10.2		17.2						
								106		47					
1977	1	295-295	295	420	1.64	0.00	64		130		237		279		
							0.0		0.0		0.0				
								66		107		42			
Total	35	Weighted Mean Length At Annulus (mm)					62		154		231		279		
		SE Mean Length (mm)					2.3		15.7		12.4		0.0		
		Mean Length Increment (mm)						92		77		48			
		Minimum Backcalculated Length (mm)					50		96		159		279		
		Maximum Backcalculated Length (mm)					116		226		256		279		
		Sample Size (n)					35		10		7		1		
		Calculated Mean Weight (g)					2		46		184		351		
		Mean Weight Increment (g)						44		138		167			

The calculated weight-length regression is $W = 1.6412 \times 10^{-6} L^{3.4048}$, ($r = 0.9921$, $P[H_0: r = 0] < 0.05$).
The calculated length-scale radius equation is $Ln = 20.2071 + 1.1137 (Sn)$ where $a = 0$, ($r = 0.9209$, $P[H_0: r = 0] < 0.05$).

Table 5c. Lake Chubsucker age and growth analysis in Site 054 for 1981.

1981

Length Interval (mm)	Number of Fish	Percent of Total	Weight (g)	Percent of Total	Mean Weight (g)	Mean KTL	Mean Wr	Age Group 0	1	2	3	4
60- 69	5	4.8	20	0.9	4.0	1.39	0.00	0	5	0	0	0
70- 79	5	4.8	22	1.0	4.6	1.25	0.00	0	5	0	0	0
80- 89	1	1.0	9	0.4	9.0	1.32	0.00	0	1	0	0	0
90- 99	10	9.5	95	4.4	9.6	1.16	0.00	0	10	0	0	0
100-109	7	6.7	107	4.9	15.4	1.22	0.00	0	7	0	0	0
110-119	42	40.0	849	38.8	20.2	1.30	0.00	0	42	0	0	0
120-129	21	20.0	546	24.9	26.0	1.36	0.00	0	21	0	0	0
130-139	11	10.5	365	16.7	33.3	1.39	0.00	0	10	1	0	0
140-149	1	1.0	43	2.0	43.0	1.57	0.00	0	1	0	0	0
150-159	0	0.0	0	0.0	0.0	0.00	0.00	0	0	0	0	0
160-169	1	1.0	54	2.5	54.0	1.29	0.00	0	0	1	0	0
170-179	1	1.0	78	3.6	78.0	1.48	0.00	0	0	1	0	0
TOTAL	105		2188		Number By Age Class			0	102	3	0	0
					% By Age Class			0	97	3	0	0
					Standard Error % By Age Class			0	2	2	0	0

Total Aged Fish 98 (93.3%)
Total Unaged Fish 7 (6.7%)

Table 6. Lake chubsucker length frequency-age distribution analysis in Site 059 for 1981.

1981

Year Class	Aged Fish	Length Range (mm)	At Capture Mean Length (mm)	At Capture Mean Weight (g)	Mean KTL	Mean Wr	Age Backcalculated Lengths (mm) With Standard Error and Increments 1		2	3	4	5
1981	0	0- 0	0	0	0.00	0.00						
1980	95	61-140	114	21	1.31	0.00	100					
							1.8					
1979	3	136-174	157	58	1.48	0.00	85		120			
							11.1					
								35				
Total	98	Weighted Mean Length At Annulus (mm)					100		120			
		SE Mean Length (mm)					1.8		11.8			
		Mean Length Increment (mm)						20				
		Minimum Backcalculated Length (mm)					50		104			
		Maximum Backcalculated Length (mm)					124		143			
		Sample Size (n)					98		3			
		Calculated Mean Weight (g)					12		22			
		Mean Weight Increment (g)						10				

The calculated weight-length regression is $W = 7.2990 \times 10^{-6} L^{3.1215}$, ($r = 0.9676$, $P[H_0{:}r = 0] < 0.05$).
The calculated length-scale radius equation is $Ln = 50.0587 + 0.6889 (Sn)$ where $a = 0$, ($r = 0.7965$, $P[H_0{:}\ r = 0] < 0.05$).

Table 7. Lake chubsucker age and growth analysis in Site 059 for 1981.

1980

Length Interval (mm)	Number of Fish	Percent of Total	Weight (g)	Percent of Total	Mean Weight (g)	Mean KTL	Mean Wr	Age Group 0	1	2	3	4
175-199	1	3.2	38	0.8	38.0	0.50	0.00	0	0	1	0	0
200-224	0	0.0	0	0.0	0.0	0.00	0.00	0	0	0	0	0
225-249	1	3.2	0	0.0	0.0	0.00	0.00	0	0	1	0	0
250-274	4	12.9	346	7.1	86.5	0.49	0.00	0	0	4	0	0
275-299	6	19.4	824	16.9	137.4	0.59	0.00	0	0	6	0	0
300-324	1	3.2	156	3.2	156.0	0.56	0.00	0	0	1	0	0
325-349	2	6.5	354	7.3	177.0	0.50	0.00	0	0	2	0	0
350-374	4	12.9	964	19.8	241.0	0.51	0.00	0	0	0	4	0
375-399	4	12.9	0	0.0	0.0	0.00	0.00	0	0	0	4	0
400-424	3	9.7	0	0.0	0.0	0.00	0.00	0	0	0	3	0
425-449	1	3.2	0	0.0	0.0	0.00	0.00	0	0	0	1	0
450-474	0	0.0	0	0.0	0.0	0.00	0.00	0	0	0	0	0
475-499	1	3.2	0	0.0	0.0	0.00	0.00	0	0	0	0	1
500-524	3	9.7	2190	45.0	730.0	0.54	0.00	0	0	0	0	3
TOTAL	31		4872		Number By Age Class			0	0	15	12	4
					% By Age Class			0	0	48	39	13
					Standard Error % By Age Class			0	0	9	9	6
								Total Aged Fish 29 (93.5%)				
								Total Unaged Fish 2 (6.5%)				

Table 8. Northern pike length frequency-age distribution analysis in Site 054 for 1980.

1980			At Capture								Age				
		Length	Mean	Mean							Backcalculated Lengths (mm)				
Year	Aged	Range	Length	Weight	Mean	Mean					With Standard Error and Increments				
Class	Fish	(mm)	(mm)	(g)	KTL	Wr	1		2		3		4		5
1980	0	0-0	0	0	0.0	0.00									
1979	0	0-0	0	0	0.0	0.00									
1978	15	196-331	276	87	0.38	0.00	149		236						
							7.1								
								87							
1977	10	355-449	394	272	0.44	0.00	156		245		345				
							7.3		8.3						
								89		100					
1976	4	490-522	508	548	0.40	0.00	233		302		395		454		
							12.7		9.3		13.1				
								69		93		59			
Total	29	Weighted Mean Length At Annulus (mm)					163		249		359		454		
		SE Mean Length (mm)					7.1		6.6		8.6		6.3		
		Mean Length Increment (mm)						86		110		95			
		Minimum Backcalculated Length (mm)						84		180		319		443	
		Maximum Backcalculated Length (mm)						270		329		433		465	
		Sample Size (n)					29		29		14		4		
		Calculated Mean Weight (g)					21		76		236		481		
		Mean Weight Increment (g)						55		160		245			

The calculated weight-length regression is $W = 3.5865 \times 10^{-6} L^{3.0586}$, ($r = 0.95289$, $P[H_0: r = 0] < 0.05$).

The calculated length-scale radius equation is $Ln = 71.0231 + 2.2330\ (Sn)$ where a = 30mm, ($r = 0.90015$, $P[H_0: r = 0] < 0.05$).

Table 9. Northern pike age and growth analysis in Site 054 for 1980.

Length Interval (mm)	No. of Fish	Age	Mean Length (mm)	Mean Weight (g)	Mean KTL	Mean Fecundity	Mean GSI
60- 69	3	1	66.3	4.0	1.39	1038	4.47
70- 79	3	1	71.6	4.7	1.25	1011	5.57
80- 89	2	1	88.0	9.0	1.32	1957	5.67
90- 99	6	1	93.8	9.7	1.16	2320	9.18
100-109	6	1	109.7	15.2	1.22	3370	7.21
110-119	13	1	117.0	21.9	1.30	3565	6.10
120-129	8	1	124.1	26.9	1.36	5032	9.53
130-139	8	1	134.6	34.6	1.39	6966	9.69
140-149	4	1	143.3	43.0	1.57	7906	8.57
150-159	0	-	-	-	-	-	-
160-169	4	2	161.7	54.5	1.29	9584	7.77
170-179	3	2	174.6	78.7	1.48	10227	6.62

Table 10. Reproduction statistics from 60 sexually mature female lake chubsuckers collected 24 March through 24 April, 1981 in Site 059.

LAKE CHUBSUCKER REPRODUCTION

Spawning Season

Gonadosomatic indices were based on examination of 123 sexually mature lake chubsuckers sampled in Site 059 during 1981. The calculated mean GSI for 24 March was 5.94 ± 1.54% (mean ± SD) at 10.25 C with all mature females possessing developing ova. At this time eggs differed in size, however they did not appear as two or more distinct modes of ova (Shireman et al. 1978) but rather as gradually decreasing in size. The GSI peaked 24 April at 9.59 ± 2.38% with a corresponding mean temperature of 15.6 C, followed by an erratic but gradual decrease to 6.92 ± 2.91% on 21 May at 14.4 C (Figure 3). The mean temperature for the entire period from 24 April through 21 May was 15.4 C. Two distinct modes of ova were present by 21 May; larger, yellow colored eggs (1.94 ± 0.213 mm, mean dia. ± SD) and smaller, white colored eggs (0.88 ± 0.18 mm) by 12 June. Coinciding with decreases in GSI was a rise in mean water temperature from 14.4 C on 21 May to 24.3 C and 23.8 on 5 June and 12 June, respectively. Ova during this period were again of two distinct modes with ripe eggs and swollen urogenital openings frequently observed. By 5 May partially spent ovaries were observed in several fish. On 5 June 30% of the mature females possessed spent ovaries. On 12 June and 19 June all ovaries from lake chubsuckers within the size range expected to be mature were spent with absorption of atretic eggs observed.

Fecundity

Fecundity was estimated for 60 sexually mature female lake chubsuckers collected in Site 059 prior to spawning (Table 10). Spawning was assumed to begin with the decrease in mean GSI between the 24 April and 29 April fish samples (Figure 3). Individual fecundity estimates ranged from 998 to 10,412 ova in mature specimens measuring 63 – 178 mm. Age 1 fish made up 88.3% of the total with age 2 fish providing the remainder.

A linear regression equation was calculated for fecundity (F) on total length (TL). The regression is described by the equation $F = 93.4385\,(TL) - 6{,}097.6201$, ($r = 0.9795$, $P[H_0{:}r=0] < 0.05$).

A linear regression equation was also calculated for fecundity on absolute weight (W_a). The regression is described by the equation $F = 93.9693\,(W_a) + 1025.6073$, ($r = 0.9672$, $P[H_0{:}r=0] < 0.05$).

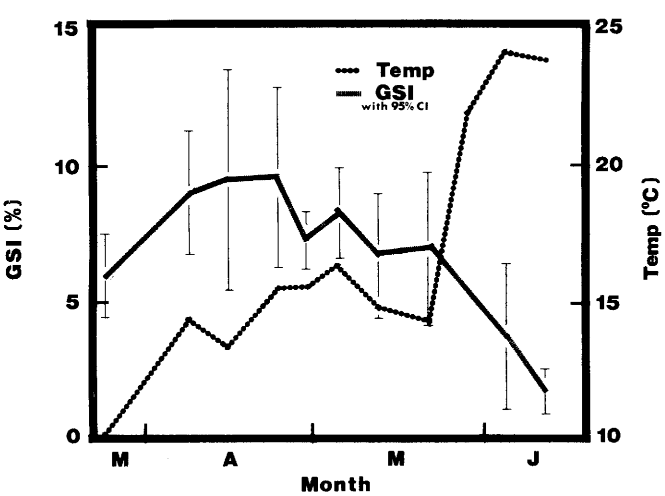

Figure 3. Changes in the mean female lake chubsucker gonadosomatic index and corresponding water temperatures in Site 059 during March - June 1981.

Sexual Maturity

Examination of 142 female lake chubsuckers collected from Site 059 between 24 March and 20 June, 1981 resulted in identification of 135 age 1 fish. Age 1 lake chubsuckers ranged in length from 52-145 mm, with all 116 fish over 100 mm (85.9%) sexually mature (Table 11). The smallest lake chubsucker identified as sexually mature was 63 mm TL.

Length Interval	No. Fish Examined	% Mature
<60	7	0
60- 69	8	37.5
70- 79	7	42.9
80- 89	3	66.0
90- 99	8	75.0
100-109	12	100
110-119	42	100
120-129	23	100
130-139	16	100
140-149	9	100
150-159	0	-
160-169	4	100
170-179	3	100
Total	142	

Table 11. Percentages of sexually mature female lake chubsuckers in Site 059, March - June 1981.

POPULATION AND BIOMASS ESTIMATES

Lake chubsucker biomass was estimated by year class during the fall of 1980 and 1981 (Table 12). The 1980 estimates indicate the 1979 year class predominated gravimetrically (67.8%) while the 1980 year class prevailed numerically (65.6%). The 1981 estimates indicate the 1979 and 1980 year classes nearly disappeared and the 1981 year class was missing entirely. Total lake chubsucker biomass declined from 67.5 kg/hectare, $P(53.6 < W_t < 87.6) = 0.95$, in 1980 to 2.2 kg/hectare, $P(0.9 < W_t < 4.81) = 0.95$, in 1981.

Largemouth bass biomass estimates were calculated during the fall of 1980 and 1981 (Table 13). The 1978 age class was prevalent throughout. The 1980 age class declined from 2,465 individuals and 24.5 kg/hectare in 1980 to 37 individuals and 4.6 kg/hectare in 1981.

Northern pike biomass was not estimated due to the difficulty in sampling an adequate number of fish. The small number sampled was interpreted as reflecting a small population. All northern pike were removed from the pond when captured in order to minimize their impact.

MORTALITY RATES

Instantaneous mortality (Z), annual mortality (A) and survival (S) were calculated from population estimates of

Year of Estimate	Year Class Estimated	$\hat{N}^a$ (95% C.I.)	$\overline{W}^b$	$\hat{B}^c$ (95% C.I.)
1980	1980	4376 (3256 - 6012)	3	18.75 (13.95 - 25.77)
	1979	2288 (1905 - 2802)	14	14.76 (38.10 - 56.04)
	1978	9 (3 - 15)	50.4	0.65 (0.22 - 1.08
	1977	9 (5 - 18)	181.8	2.34 (1.30 - 4.67)
			Total	67.5 (53.57 - 87.56)
1981	1981	0	-	-
	1980	47 (23 - 102)	15	1.01 (0.49 - 2.19)
	1979	1 (0.1)	22	0.03 (0 - 0.03)
	1978	3 (1.7)	258	1.11 (0.37 - 2.58)
			Total	2.15 (0.86 - 4.80)

[a]$\hat{N}$ represents the population estimate using a modified Schnabel technique.

[b]$\overline{W}$ represents the mean weight (g) of an individual of that age class.

[c]$\hat{B}$ represents the biomass estimate (kg/hectare) of each age class.

Table 12. Site 054 lake chubsucker biomass estimates for 1980 and 1981 with 95% confidence intervals.

Year of Estimate	Year Class Estimated	$\hat{N}^a$ (95% C.I.)	$\overline{W}^b$	$\hat{B}^c$ (95% C.I.)
1980	1980	2465 (1739 - 4235)	7	24.5 (17.3 - 42.0)
	1978	104 (76 - 163)	480	70.7 (51.7 - 110.9)
			Total	95.2 (68.6 - 152.9)
1981	1981	1383 (1163 - 1706)	7	13.3 (11.5 - 16.9)
	1980	37 (27 - 59)	88	4.6 (3.4 - 7.4)
	1978	58 (47 - 77)	491	40.4 (32.7 - 53.6)
			Total	58.7 (47.6 - 77.9)

[a] $\hat{N}$ represents the population estimate using a modified Schnabel technique.

[b] $\overline{W}$ represents the mean weight (g) of an individual of that age class.

[c] $\hat{B}$ represents the biomass estimate (kg/hectare) of each age class.

Table 13. Site 054 largemouth bass biomass estimates for 1980 and 1981 with 95% confidence limits.

Age Class	1980	1981	Z	A	S
Lake Chubsuckers					
1978	9	3	1.09861	0.66667	0.33333
1979	2288	1	7.73193	0.99956	0.00044
1980	4376	47	4.53374	0.98926	0.01074
Largemouth Bass					
1978	104	58	0.58395	0.44231	0.55769
1980	2465	37	4.19903	0.98499	0.01501

Table 14. Instantaneous mortality, annual mortality and survival of 1978, 1979 and 1980 age classes of lake chubsuckers and 1978 and 1980 age classes of largemouth bass.

1978, 1979 and 1980 year classes of lake chubsuckers and 1978 and 1980 year classes of largemouth bass (Table 14).

FOOD HABITS

During 1979-1981, 407 largemouth bass and 140 lake chubsucker stomachs were examined for food contents. During 1980, 29 northern pike stomachs were examined for food contents. Two hundred fourteen (52.6%) largemouth bass, 124 (88.6%) lake chubsucker and 12 (41.4%) northern pike stomachs contained food. Individuals of each species were grouped in 50 mm size increments and examined by year and entire study period.

Largemouth Bass

Largemouth bass 0-49 mm fed exclusively on crustaceans, dominated numerically by the bosminids and gravimetrically by the daphnids (Table 15). Crustaceans appeared in stomach samples of all other sizes, however, they never contributed more than 5.5% by weight.

Insects were present in all largemouth bass stomachs examined except 0-49 mm individuals. Libellulid odonates consistently dominated the insect weight in the largemouth bass stomach samples, reaching greatest proportion in 50-99 mm individuals (Table 16). Largemouth bass 50-200 mm primarily consumed libellulid nymphs, while larger fish consumed greater quantities of adults.

Fish first appeared in the diets of 150-199 mm largemouth bass, contributing 1.1% and 54.0% by number and weight, respectively (Table 17). This size group was also the first to have northern pike in their diet, forming 0.2% and 17.1% by number and weight, respectively. Lake chubsuckers were most frequently consumed by 200-249 mm largemouth bass (Table 18) while occurring in the stomach samples of all size groups 199 mm and larger.

Largemouth bass of the 250-299 mm size group possessed all three fish species in their diets in 1980, with lake chubsuckers dominating by weight at 26.5% (Table 19).

Cannibalism was most frequent among 300-349 mm largemouth bass. Stomach samples, represented 3.0% and 14.1% of their diet by number and weight, respectively (Table 20). While all three fish species occurred in the largemouth bass diets at some time during the study, lake chubsuckers were again the most common.

	1979						1980						1981						Total					
	Freq. of Occurrence No.	%	By Number No.	%	By Weight Grams	%	Freq. of Occurrence No.	%	By Number No.	%	By Weight Grams	%	Freq. of Occurrence No.	%	By Number No.	%	By Weight Grams	%	Freq. of Occurrence No.	%	By Number No.	%	By Weight Grams	%
Crustacea													73	99.9	9595	99.9	0.63	99.9	73	99.9	9595	99.9	0.63	99.9
Amphipoda													73	99.9	13	0.1	0.01	2.0	73	99.9	13	0.1	0.01	2.0
Gammaridae													73	99.9	13	0.1	0.01	2.0	73	99.9	13	0.1	0.01	2.0
Cladocera													73	99.9	8468	88.3	0.53	83.9	73	99.9	8468	88.3	0.53	83.9
Daphnidae													73	99.9	657	6.8	0.51	81.8	73	99.9	657	6.8	0.51	81.8
Bosminidae													73	99.9	7811	81.4	0.01	2.1	73	99.9	7811	81.4	0.01	2.1
Copepoda													73	99.9	896	9.3	0.03	5.0	73	99.9	896	9.3	0.03	5.0
Calanoida													73	99.9	511	5.3	0.01	1.8	73	99.9	511	5.3	0.01	1.8
Cyclopoida													73	99.9	385	4.0	0.02	3.3	73	99.9	385	4.0	0.02	3.3
Podocopa													73	99.9	218	2.3	0.06	9.1	73	99.9	218	2.3	0.06	9.1

Table 15. Food items found in 0-49 mm largemouth bass from Site 054 during 1981.

	1979						1980						1981						Total					
	Freq. of Occurrence No.	%	By Number No.	%	By Weight Grams	%	Freq. of Occurrence No.	%	By Number No.	%	By Weight Grams	%	Freq. of Occurrence No.	%	By Number No.	%	By Weight Grams	%	Freq. of Occurrence No.	%	By Number No.	%	By Weight Grams	%
Insecta							13	100.0	89	8.3	0.78	50.6	55	100.0	1759	80.3	16.76	97.9	68	100.0	1848	56.7	17.55	94.0
Ephemeroptera							10	76.9	21	2.0	0.03	1.7	33	60.0	183	8.4	0.23	1.3	43	63.2	204	6.3	0.26	1.4
Baetidae							10	76.9	18	1.7	0.02	1.5	33	60.0	183	8.4	0.23	1.3	43	63.2	201	6.2	0.25	1.4
Caenidae							3	23.1	3	0.3	0.00	0.2							3	4.4	3	0.1	0.00	0.0
Odonata							13	100.0	68	6.4	0.76	48.9	55	100.0	714	32.6	15.29	89.3	68	100.0	782	24.0	16.05	86.0
Anisoptera																								
Libellulidae							9	69.2	19	1.8	0.63	40.7	33	60.0	432	19.7	14.32	83.7	42	61.8	451	13.8	14.95	80.1
Zygoptera																								
Coenagriidae							12	92.3	49	4.6	0.13	8.2	36	65.5	282	12.9	0.97	5.6	48	70.6	331	10.2	1.09	5.9
Diptera													22	40.0	744	34.0	0.30	1.7	22	32.4	744	22.8	0.30	1.6
Chironomidae													22	40.0	417	19.0	0.15	0.9	22	32.4	417	12.8	0.15	0.8
Simuliidae													22	40.0	111	5.1	0.03	0.2	22	32.4	111	3.0	0.03	0.1
Chaoboridae													22	40.0	216	9.9	0.12	0.7	22	32.4	216	6.6	0.12	0.6
Hemiptera													55	100.0	118	5.4	0.95	5.5	55	80.9	118	3.6	0.95	5.1
Corixidae													33	60.0	86	3.9	0.71	4.1	33	48.5	86	2.6	0.71	3.8
Gerridae													22	40.0	19	0.9	0.14	0.8	22	32.4	19	0.6	0.14	0.7
Saldidae													22	40.0	13	0.6	0.10	0.6	22	32.4	13	0.4	0.10	0.5
Crustacea							10	76.9	980	91.7	0.77	49.4	55	100.0	431	19.7	0.36	2.1	65	95.6	1411	43.3	1.12	6.0
Amphipoda							5	38.5	8	0.7	0.01	0.5	33	60.0	122	5.6	0.11	0.7	38	55.9	130	4.0	0.12	0.7
Gammaridae							5	38.5	8	0.7	0.01	0.5	33	60.0	122	5.6	0.11	0.7	38	55.9	130	4.0	0.12	0.7
Cladocera							10	76.9	972	90.9	0.76	49.0	36	65.5	309	14.1	0.24	1.4	46	67.6	1281	39.3	1.00	5.4
Daphnidae							10	76.9	972	90.9	0.76	49.0	36	65.5	309	14.1	0.24	1.4	46	67.6	1281	39.3	1.00	5.4

Table 16. Food items found in 50-99 mm largemouth bass from Site 054 during 1980-1981.

	1979						1980						1981						Total					
	Freq. of Occurrence		By Number		By Weight		Freq. of Occurrence		By Number		By Weight		Freq. of Occurrence		By Number		By Weight		Freq. of Occurrence		By Number		By Weight	
	No.	%	No.	%	Grams	%	No.	%	No.	%	Grams	%	No.	%	No.	%	Grams	%	No.	%	No.	%	Grams	%
Osteichthyes	1	33.3	1	0.2	0.19	17.1							4	100.0	5	6.5	1.27	17.1	5	71.4	6	1.1	1.46	54.0
Mesichthyes																								
Esocidae	1	33.3	1	0.2	0.19	17.1													1	14.3	1	0.2	0.19	7.1
Esox lucius	1	33.3	1	0.2	0.19	17.1													1	14.3	1	0.2	0.19	7.1
Acanthopterygii																								
Centrarchidae													4	100.0	5	6.5	1.27	80.0	4	57.1	5	0.9	1.27	46.9
Micropterus salmoides													4	100.0	5	6.5	1.27	80.0	4	57.1	5	0.9	1.27	46.9
Insecta	3	100.0	464	94.9	0.90	80.5							4	100.0	41	53.2	0.29	18.5	7	100.0	505	89.2	1.20	44.2
Ephemeroptera	3	100.0	44	9.0	0.06	4.9							3	75.0	17	22.1	0.07	4.3	6	85.7	61	10.8	0.12	4.6
Baetidae	3	100.0	44	9.0	0.06	4.9													3	42.9	44	7.8	0.06	2.0
Ephemeridae													3	75.0	17	22.1	0.07	4.3	3	42.9	17	3.0	0.07	2.5
Trichoptera													1	25.0	6	7.8	0.01	0.3	1	14.3	6	1.1	0.01	0.2
Brachycentridae													1	25.0	6	7.8	0.01	0.3	1	14.3	6	1.1	0.01	0.2
Odonata	3	100.0	19	3.9	0.16	14.6							3	75.0	7	9.1	0.13	8.3	6	85.7	26	4.6	0.30	10.9
Anisoptera																								
Aeshnidae	1	33.3	1	0.2	0.01	0.7							2	50.0	4	5.2	0.03	2.0	3	42.9	5	0.9	0.04	1.5
Libellulidae	2	66.7	3	0.6	0.10	8.9							2	50.0	3	3.9	0.10	6.3	4	57.1	6	1.1	0.20	7.3
Zygoptera																								
Coenagriidae	3	100.0	15	3.1	0.06	5.1													3	42.9	15	2.7	0.06	2.1
Diptera	2	66.7	337	68.9	0.17	14.9													2	28.6	337	59.5	0.17	6.2
Chironomidae	2	66.7	3	0.6	0.00	0.1													2	28.6	3	0.5	0.00	0.0
Culicidae	1	33.3	161	32.9	0.08	6.8													1	14.3	161	28.4	0.08	2.8
Chaoboridae	2	66.7	164	33.5	0.09	7.9													2	28.6	164	29.0	0.09	3.3
Ceratopogonidae	1	33.3	9	1.8	0.00	0.1													1	14.3	9	1.6	0.00	0.0
Hemiptera	3	100.0	64	13.1	0.52	46.1							2	50.0	11	14.3	0.09	5.6	5	71.4	75	13.3	0.60	22.3
Corixidae	3	100.0	49	10.0	0.40	36.1													1	14.3	6	1.1	0.04	1.6
Gerridae	1	33.3	6	1.2	0.04	3.8													1	14.3	6	1.1	0.04	1.6
Nepidae													2	50.0	11	14.3	0.09	5.6	2	28.6	11	1.9	0.09	3.3
Saldidae	1	33.3	9	1.8	0.07	6.1													1	14.3	9	1.6	0.07	2.5
Crustacea	3	100.0	22	4.5	0.02	1.6							3	75.0	31	40.3	0.02	1.5	6	85.7	53	9.4	0.04	1.5
Amphipoda	1	33.3	2	0.4	0.00	0.2													1	14.3	2	0.4	0.00	0.1
Gammaridae	1	33.3	2	0.4	0.00	0.2													1	14.3	2	0.4	0.00	0.1
Cladocera	2	66.7	20	4.1	0.02	1.4							3	75.0	31	40.3	0.02	1.5	5	71.4	51	9.0	0.04	1.5
Daphnidae	2	66.7	20	4.1	0.02	1.4							3	75.0	27	35.1	0.02	1.3	5	71.4	47	8.3	0.04	1.4
Arachnoidea	1	33.3	1	0.2	0.00	0.0													1	14.3	1	0.2	0.00	0.0
Hydracarina	1	33.3	1	0.2	0.00	0.0													1	14.3	1	0.2	0.00	0.0
Molluska	1	33.3	1	0.2	0.01	0.8													1	14.3	1	0.2	0.01	0.3
Gastropoda	1	33.3	1	0.2	0.01	0.8													1	14.3	1	0.2	0.01	0.3

Table 17. Food items found in 150-199 mm largemouth bass from Site 054 during 1979 and 1981.

	1979						1980						1981						Total					
	Freq. of Occurrence		By Number		By Weight		Freq. of Occurrence		By Number		By Weight		Freq. of Occurrence		By Number		By Weight		Freq. of Occurrence		By Number		By Weight	
	No.	%	No.	%	Grams	%	No.	%	No.	%	Grams	%	No.	%	No.	%	Grams	%	No.	%	No.	%	Grams	%
Osteichthyes	11	73.3	22	1.0	0.88	8.8	1	100.0	1	33.3	1.23	99.4							12	75.0	23	1.1	2.11	18.9
Ostariophysii																								
Catostomidae	11	73.3	22	1.0	0.88	8.8	1	100.0	1	33.3	1.23	99.4							12	75.0	23	1.1	2.11	18.9
Erimyzon sucetta	11	73.3	22	1.0	0.88	8.8	1	100.0	1	33.3	1.23	99.4							12	75.0	23	1.1	2.11	18.9
Insecta	15	100.0	1990	93.2	8.24	82.9	1	100.0	2	66.7	0.01	0.6							16	100.0	1992	93.1	8.25	73.8
Ephemeroptera	15	100.0	456	21.3	0.57	5.8													15	93.8	456	21.3	0.57	5.1
Baetidae	15	100.0	456	21.3	0.57	5.8													15	93.8	456	21.3	0.57	5.1
Trichoptera	10	66.7	5	0.2	0.00	0.0													10	62.5	5	0.2	0.00	0.0
Hydroptilidae	1	6.7	1	0.0	0.00	0.0													1	6.3	1	0.0	0.00	0.0
Limnephilidae	9	60.0	4	0.2	0.00	0.0													9	56.3	4	0.2	0.00	0.0
Odonata	15	100.0	345	16.2	6.32	63.5	1	100.0	2	66.7	0.01	0.6							16	100.0	347	16.2	6.32	56.6
Anisoptera																								
Aeshnidae	12	80.0	40	1.9	0.32	3.2													12	75.0	40	1.9	0.32	2.9
Libellulidae	13	86.7	107	5.0	5.22	52.5													13	81.3	107	5.0	5.22	46.7
Zygoptera	8	53.3	10	0.5	0.03	0.3													8	50.0	10	0.5	0.03	0.3
Coenagriidae	15	100.0	188	8.8	0.74	7.5	1	100.0	2	66.7	0.01	0.6							16	100.0	190	8.9	0.75	6.7
Diptera	12	80.0	1080	50.6	0.55	5.5													12	75.0	1080	50.5	0.55	4.9
Chironomidae	12	80.0	14	0.7	0.01	0.1													12	75.0	14	0.7	0.01	0.0
Culicidae	2	13.3	385	18.0	0.18	1.8													2	12.5	385	18.0	0.18	1.6
Chaoboridae	11	73.3	671	31.4	0.36	3.6													11	68.8	671	31.4	0.36	3.2
Ceratopogonidae	8	53.3	10	0.5	0.00	0.0													8	50.0	10	0.5	0.00	0.0
Coleoptera	12	80.0	11	0.5	0.03	0.3													12	75.0	11	0.5	0.03	0.3
Dytiscidae	4	26.7	9	0.4	0.00	0.0													4	25.0	9	0.4	0.00	0.0
Hydrophilidae	8	53.3	2	0.1	0.03	0.3													8	50.0	2	0.1	0.03	0.3
Hemiptera	13	86.7	93	4.4	0.77	7.7													13	81.3	93	4.3	0.77	6.8
Corixidae	13	86.7	88	4.1	0.73	7.3													13	81.3	88	4.1	0.73	6.5
Saldidae	9	60.0	5	0.2	0.04	0.4													9	56.3	5	0.2	0.04	0.3
Crustacea	11	73.3	67	3.1	0.61	6.2													11	68.8	67	3.1	0.61	5.5
Decapoda	1	6.7	1	0.0	0.56	5.7													1	6.3	1	0.0	0.56	5.0
Amphipoda	10	66.7	13	0.6	0.01	0.1													10	62.5	13	0.6	0.01	0.1
Gammaridae	10	66.7	13	0.6	0.01	0.1													10	62.5	13	0.6	0.01	0.1
Cladocera	10	66.7	47	2.2	0.04	0.4													10	62.5	47	2.2	0.04	0.3
Daphnidae	10	66.7	47	2.2	0.04	0.4													10	62.5	47	2.2	0.04	0.3
Podocopa	8	53.3	6	0.3	0.00	0.0													8	50.0	6	0.3	0.00	0.0
Molluska	12	80.0	15	0.7	0.14	1.4													12	75.0	15	0.7	0.14	1.3
Gastropoda	12	80.0	12	0.6	0.11	1.1													12	75.0	12	0.6	0.11	0.9
Basommatophora																								
Physidae	1	6.7	6	0.3	0.05	0.5													1	6.3	6	0.3	0.05	0.5
Pelecypoda	8	53.3	3	0.1	0.03	0.3													8	50.0	3	0.1	0.03	0.3
Sphaeriidae	8	53.3	3	0.1	0.03	0.3													8	50.0	3	0.1	0.03	0.3
Annelida	8	53.3	1	0.0	0.01	0.1													8	50.0	1	0.0	0.01	0.1
Hirudinea	8	53.3	1	0.0	0.01	0.1													8	50.0	1	0.0	0.01	0.1
Detritus	1	6.7	41	1.9	0.06	0.6													1	6.3	41	1.9	0.06	0.6

Table 18. Food items found in 200-249 mm largemouth bass from Site 054 during 1979-1980.

	1979						1980						1981						Total					
	Freq. of Occurrence		By Number		By Weight		Freq. of Occurrence		By Number		By Weight		Freq. of Occurrence		By Number		By Weight		Freq. of Occurrence		By Number		By Weight	
	No.	%	No.	%	Grams	%	No.	%	No.	%	Grams	%	No.	%	No.	%	Grams	%	No.	%	No.	%	Grams	%
Osteichthyes	8	66.7	1	0.2	0.51	4.3	11	78.6	16	1.1	8.09	57.6							18	72.0	17	0.8	8.60	33.0
Mesichthyes																								
Esocidae	8	66.7	1	0.2	0.51	4.3	2	14.3	2	0.1	0.95	6.8							2	8.0	2	0.1	0.95	3.6
Esox lucius	8	66.7	1	0.2	0.51	4.3	2	14.3	2	0.1	0.95	6.8							2	8.0	2	0.1	0.95	3.6
Acanthopterygii																								
Centrarchidae							4	28.6	6	0.4	0.76	5.4							4	16.0	6	0.3	0.76	2.9
Micropterus salmoides							4	28.6	6	0.4	0.76	5.4							4	16.0	6	0.3	0.76	2.9
Ostariophysii																								
Catostomidae							7	50.0	8	0.6	6.38	45.5							14	56.0	9	0.4	6.90	26.5
Erimyzon sucetta							7	50.0	8	0.6	6.38	45.5							14	56.0	9	0.4	6.90	26.5
Insecta	12	100.0	552	92.0	10.54	87.6	14	100.0	493	34.0	5.27	37.6							25	100.0	1045	51.0	15.81	60.7
Ephemeroptera	10	83.3	184	30.7	0.23	1.9	10	71.4	102	7.0	0.13	0.9							19	76.0	286	13.9	0.36	1.4
Baetidae	10	83.3	184	30.7	0.23	1.9	10	71.4	102	7.0	0.13	0.9							19	76.0	286	13.9	0.36	1.4
Trichoptera	8	66.7	2	0.3	0.00	0.0													8	32.0	2	0.1	0.00	0.0
Limnephilidae	8	66.7	2	0.3	0.00	0.0													8	32.0	2	0.1	0.00	0.0
Odonata	12	100.0	180	30.0	9.75	81.0	11	78.6	48	3.3	3.57	25.4							22	88.0	228	11.1	13.31	51.1
Anisoptera																								
Aeshnidae	9	75.0	64	10.7	0.49	4.1													9	36.0	64	3.1	0.49	1.9
Libellulidae	12	100.0	41	6.8	8.03	66.7	9	64.3	26	1.8	3.48	24.8							20	80.0	67	3.3	11.52	44.2
Zygoptera																								
Coenagriidae	11	91.7	63	10.5	0.25	2.1	6	42.9	22	1.5	0.08	0.6							17	68.0	85	4.1	0.33	1.3
Diptera	9	75.0	120	20.0	0.06	0.5	8	57.1	324	22.3	0.13	0.9							17	68.0	444	21.6	0.19	0.7
Chironomidae	8	66.7	3	0.5	0.00	0.0	2	14.3	169	11.6	0.06	0.4							10	40.0	172	8.4	0.06	0.2
Culicidae							2	14.3	4	0.3	0.00	0.0							2	8.0	4	0.2	0.00	0.0
Syrphidae							2	14.3	2	0.1	0.00	0.0							2	8.0	2	0.1	0.00	0.0
Chaoboridae	9	75.0	105	17.5	0.06	0.5													9	36.0	105	5.1	0.06	0.2
Ceratopogonidae	8	66.7	12	2.0	0.00	0.0	2	14.3	18	1.2	0.00	0.0							10	40.0	30	1.5	0.00	0.0
Coleoptera	9	75.0	2	0.3	0.03	0.3	2	14.3	2	0.1	0.02	0.1							11	44.0	4	0.2	0.05	0.2
Dytiscidae							1	7.1	1	0.1	0.00	0.0							1	4.0	1	0.0	0.00	0.0
Gyrinidae							1	7.1	1	0.1	0.02	0.1							1	4.0	1	0.0	0.02	0.1
Hydrophilidae	9	75.0	2	0.3	0.03	0.3													9	36.0	2	0.1	0.03	0.1
Hemiptera	9	75.0	64	10.7	0.47	3.9	5	35.7	15	1.0	0.14	1.0							14	56.0	79	3.9	0.61	2.3
Corixidae							4	28.6	12	0.8	0.10	0.7							4	16.0	12	0.6	0.10	0.4
Gerridae	8	66.7	62	10.3	0.44	3.7													8	32.0	62	3.0	0.44	1.7
Nepidae	1	8.3	1	0.2	0.01	0.1	1	7.1	1	0.1	0.01	0.1							2	8.0	2	0.1	0.02	0.1
Notonectidae	8	66.7	1	0.2	0.02	0.1	1	7.1	2	0.1	0.04	0.3							9	36.0	3	0.1	0.05	0.2
Orthoptera							2	14.3	2	0.1	1.29	9.2							2	8.0	2	0.1	1.29	4.9
Crustacea	11	91.7	22	3.7	0.02	0.1	10	71.4	938	64.6	0.35	2.5							20	80.0	960	46.8	0.37	1.4
Amphipoda	10	83.3	13	2.2	0.01	0.1	5	35.7	100	6.9	0.09	0.7							15	600.0	113	5.5	0.11	0.4
Gammaridae	10	83.3	13	2.2	0.01	0.1	5	35.7	100	6.9	0.09	0.7							15	60.0	113	5.5	0.11	0.4
Cladocera	8	66.7	1	0.2	0.00	0.0	7	50.0	263	18.1	0.21	1.5							14	56.0	264	12.9	0.21	0.8
Daphnidae	8	66.7	1	0.2	0.00	0.0	6	42.9	262	18.1	0.20	1.5							13	52.0	263	12.8	0.21	0.8
Copepoda							4	28.6	446	30.7	0.02	0.1							4	16.0	446	21.7	0.02	0.1
Calanoida							2	14.3	170	11.7	0.00	0.0							2	8.0	170	8.3	0.00	0.0
Cyclopoida							3	21.4	276	19.0	0.01	0.1							3	12.0	276	13.5	0.01	0.1
Podocopa	9	75.0	8	1.3	0.00	0.0	5	35.7	129	8.9	0.03	0.2							13	52.0	137	6.7	0.04	0.1
Mollusca	10	83.3	6	1.0	0.05	0.4	1	7.1	3	0.2	0.31	2.2							11	44.0	9	0.4	0.36	0.4
Gastropoda	10	83.3	6	1.0	0.05	0.4													10	40.0	6	0.3	0.05	0.2
Basommatophora																								
Physidae	1	8.3	1	0.2	0.01	0.1													1	4.0	1	0.0	0.01	0.0
Pelecypoda							1	7.1	3	0.2	0.31	2.2							1	4.0	3	0.1	0.31	1.2
Sphaeriidae							1	7.1	3	0.2	0.31	2.2							1	4.0	3	0.1	0.31	1.2
Annelida	9	75.0	3	0.5	0.85	7.1	1	7.1	1	0.1	0.01	0.1							10	40.0	4	0.2	0.86	3.3
Oligochaeta	1	8.3	1	0.2	0.84	7.0													1	4.0	1	0.0	0.84	3.2
Hirudinea	8	66.7	2	0.3	0.01	0.1	1	7.1	1	0.1	0.01	0.1							9	36.0	3	0.1	0.02	0.1
Detritus	1	8.3	16	2.7	0.06	0.5													1	4.0	16	0.8	0.06	0.2

Table 19. Food items found in 250-299 mm largemouth bass from Site 054 during 1979-1980.

	1979						1980						1981						Total					
	Freq. of Occurrence		By Number		By Weight		Freq. of Occurrence		By Number		By Weight		Freq. of Occurrence		By Number		By Weight		Freq. of Occurrence		By Number		By Weight	
	No.	%	No.	%	Grams	%	No.	%	No.	%	Grams	%	No.	%	No.	%	Grams	%	No.	%	No.	%	Grams	%
Osteichthyes							8	88.9	16	0.7	6.04	58.1	10	62.5	93	8.3	4.84	24.6	18	72.0	109	3.3	10.88	36.2
Mesichthyes																								
Esocidae													1	6.3	1	0.1	0.21	1.1	1	4.0	1	0.0	0.21	0.7
Esox lucius													1	6.3	1	0.1	0.21	1.1	1	4.0	1	0.0	0.21	0.7
Acanthopterygii																								
Centrarchidae							6	66.7	10	0.5	1.48	14.2	9	56.3	91	8.1	2.74	14.0	15	60.0	101	3.0	4.22	14.1
Micropterus salmoides							6	66.7	10	0.5	1.48	14.2	9	56.3	91	8.1	2.74	14.0	15	60.0	101	3.0	4.22	14.1
Ostariophysii																								
Catostomidae							5	55.6	6	0.3	4.56	43.9	1	6.3	1	0.1	1.88	9.6	6	24.0	7	0.2	6.45	21.5
Erimyzon sucetta							5	55.6	6	0.3	4.56	43.9	1	6.3	1	0.1	1.88	9.6	6	24.0	7	0.2	6.45	21.5
Replitia							1	11.1	1	0.0	1.19	11.5							1	4.0	1	0.0	1.19	4.0
Mammalia													1	6.3	1	0.1	7.84	39.9	1	4.0	1	0.0	7.84	26.1
Insecta							9	100.0	331	14.9	2.31	22.2	16	100.0	253	22.5	6.64	33.8	25	100.0	584	17.5	8.95	29.8
Ephemeroptera							6	66.7	36	1.6	0.05	0.5	5	31.3	14	1.2	0.02	0.1	11	44.0	50	1.5	0.07	0.2
Baetidae							5	55.6	34	1.5	0.04	0.4	5	31.3	14	1.2	0.02	0.1	10	40.0	48	1.4	0.06	0.2
Caenidae							1	11.1	1	0.0	0.00	0.0							1	4.0	1	0.0	0.00	0.0
Ephemeridae							1	11.1	1	0.0	0.00	0.0							1	4.0	1	0.0	0.00	0.0
Trichoptera													2	12.5	9	0.8	0.01	0.0	2	8.0	9	0.3	0.01	0.0
Leptoceridae													2	12.5	9	0.8	0.01	0.0	2	8.0	9	0.3	0.01	0.0
Odonata							6	66.7	41	1.8	2.00	19.3	16	100.0	135	12.0	6.22	31.7	22	88.0	176	5.3	8.23	27.4
Anisoptera																								
Aeshnidae							1	11.1	2	0.1	0.02	0.2	1	6.3	1	0.1	0.01	0.0	2	8.0	3	0.1	0.02	0.1
Libellulidae							5	55.6	22	1.0	1.92	18.5	15	93.8	79	7.0	6.02	30.6	20	80.0	101	3.0	7.94	26.4
Zygoptera																								
Coenagriidae							3	33.3	17	0.8	0.07	0.6	9	56.3	55	4.9	0.20	1.0	12	48.0	72	2.2	0.27	0.9
Diptera							8	88.9	242	10.9	0.14	1.3	5	31.3	86	7.7	0.03	0.2	13	52.0	328	9.8	0.17	0.6
Chironomidae							7	77.8	188	8.5	0.07	0.7	3	18.8	81	7.2	0.03	0.2	10	40.0	269	8.0	0.10	0.3
Culicidae							1	11.1	2	0.1	0.00	0.0							1	4.0	2	0.1	0.00	0.0
Simuliidae							2	22.2	3	0.1	0.00	0.0	3	18.8	5	0.4	0.00	0.0	5	20.0	8	0.2	0.00	0.0
Syrphidae							1	11.1	2	0.1	0.00	0.0							1	4.0	2	0.1	0.00	0.0
Chaoboridae							1	11.1	3	0.1	0.00	0.0							1	4.0	3	0.1	0.00	0.0
Ceratopogonidae							4	44.4	25	1.1	0.00	0.0							4	16.0	25	0.7	0.00	0.0
Coleoptera							4	44.4	4	0.2	0.06	0.5	6	37.5	9	0.8	0.37	1.9	10	40.0	13	0.4	0.42	1.4
Chrysomelidae							1	11.1	1	0.0	0.00	0.0							1	4.0	1	0.0	0.00	0.0
Dytiscidae							2	22.2	2	0.1	0.00	0.0	1	6.3	1	0.1	0.00	0.0	3	12.0	3	0.1	0.00	0.0
Gyrinidae													1	6.3	2	0.2	0.03	0.2	1	4.0	2	0.1	0.03	0.1
Hydrophilidae							1	11.1	1	0.0	0.06	0.5	5	31.3	6	0.5	0.33	1.7	6	24.0	7	0.2	0.39	1.3
Hemiptera							4	44.4	8	0.4	0.06	0.6							4	16.0	8	0.2	0.06	0.2
Corixidae							2	22.2	4	0.2	0.03	0.3							2	8.0	4	0.1	0.03	0.1
Gerridae							1	11.1	1	0.0	0.01	0.1							1	4.0	1	0.0	0.01	0.0
Notonectidae							1	11.1	1	0.0	0.02	0.2							1	4.0	1	0.0	0.02	0.1
Miridae							1	11.1	2	0.1	0.00	0.0							1	4.0	2	0.1	0.00	0.0
Crustacea							7	77.8	1872	84.2	0.84	8.1	4	25.0	776	69.0	0.31	1.6	11	44.0	2648	79.1	1.15	3.8
Amphipoda							1	11.1	6	0.3	0.01	0.1							1	4.0	6	0.2	0.01	0.0
Gammaridae							1	11.1	6	0.3	0.01	0.1							1	4.0	6	0.2	0.01	0.0
Cladocera							6	66.7	886	39.9	0.69	6.6	3	18.8	367	32.7	0.29	1.5	9	36.0	1253	37.4	0.97	3.2
Daphnidae							6	66.7	856	38.5	0.67	6.4	3	18.8	367	32.7	0.29	1.5	9	36.0	1223	36.6	0.95	3.2
Copepoda							5	55.6	465	20.9	0.02	0.2	3	18.8	389	34.6	0.02	0.1	8	32.0	854	25.5	0.03	0.1
Calanoida							4	44.4	262	11.8	0.01	0.1	2	12.5	178	15.8	0.00	0.0	6	24.0	440	13.2	0.01	0.0
Cyclopoida							3	33.3	203	9.1	0.01	0.1	3	18.8	211	18.8	0.01	0.1	6	24.0	414	12.4	0.02	0.1
Podocopa							6	66.7	515	23.2	0.14	1.3	1	6.3	20	1.8	0.01	0.0	7	28.0	535	16.0	0.14	0.5
Arachnoidea							1	11.1	1	0.0	0.00	0.0							1	4.0	1	0.0	0.00	0.0
Hydracarina							1	11.1	1	0.0	0.00	0.0							1	4.0	1	0.0	0.00	0.0
Annelida							1	11.1	1	0.0	0.01	0.1	1	6.3	1	0.1	0.01	0.0	2	8.0	2	0.1	0.01	0.0
Hirudinea							1	11.1	1	0.0	0.01	0.1	1	6.3	1	0.1	0.01	0.0	2	8.0	2	0.1	0.01	0.0

Table 20. Food items found in 300-349 mm largemouth bass from Site 054 during 1980-1981.

Lake Chubsucker

Insects and crustaceans were found in all lake chubsucker stomachs sampled. Cladocerans, of Bosminidae and Daphnidae, dominated food items of 50-99 mm lake chubsuckers (Table 21). Daphnia were important food items by weight in diets of all size groups examined except 150-199 mm lake chubsuckers.

Daphnid crustaceans dominated food items of 100-149 mm lake chubsuckers in 1980, however mollusks dominated by weight in 1981, contrasting a low corresponding numerical contribution (Table 22). Numerical contribution seems the more appropriate value for consideration of mollusks importance to the lake chubsucker diet however, since much of the weight is tied up in indigestible shell. Daphnids and several dipterans were of approximately equal importance to lake chubsucker diets.

Mollusks dominated the 150-199 mm lake chubsucker diets by weight (82.2%) with gastropods contributing 56.2% and sphaeriid pelecypods contributing 26.1% (Table 23).

Gastropods contributed 11.2% by number over the three year time period, indicating they were not ingested incidentally. Crustaceans represented 79.3% of the diet by number overall, occurring in all lake chubsucker stomachs of this size.

Crustaceans were the most numerous organisms found in the stomach samples of 200-249 mm lake chubsuckers, with the family Bosminidae dominating numerically (61.1%) but contributed only 0.3% by weight (Table 24). Daphnids contributed 9.1% numerically and 23.7% by weight while gammarid amphipods contributed 3.8% and 11.8% by number and weight, respectively.

Coenagriid odonates were the most dominant insects by weight in the diets of 200-249 mm lake chubsuckers, although haliplid coleopterans contributed substantially (Table 24).

Northern Pike

Insects were present in stomachs of all size groups examined with libellulids represented in all but 150-199 mm fish (Table 25). The single 150-199 mm northern pike was the only specimen to contain crustaceans, having consumed 114 daphnids. Fish were found in the diets of all size groups except 150-199 mm. Largemouth bass were represented in each size group except 300-349 mm while lake chubsuckers were found in the diets of 250-349 mm and 400-449 mm northern pike. Cannibalism was not documented in Site 054 northern pike.

PHYSIOCHEMICAL POND CHARACTERISTICS

Site 054 temperature profiles indicate a weak thermocline developed during July and August of 1979 and 1981 (Appendix A, Figure 1). Corresponding DO profiles support this observation (Appendix A, Figure 2), however stratification is weak and deep enough that most of the water can support fish anytime during the growing season. Since measurements were not taken, it is not known whether this phenomenon occurred during July and August of 1980.

Profiles developed for Site 059 in 1981 indicate strong thermal stratification by 5 June (Appendix A, Figure 3). Corresponding DO profiles indicate a substantial portion of the water column is unable to support fish during this period (Appendix A, Figure 4). Profiles indicate spring overturn occurred prior to 8 April 1981.

Total hardness in Site 054 varied from 86 mg/liter in June 1980 to 238 mg/liter in November 1981, with 120-238 mg/liter during 1981 representing the greatest seasonal variation (Figure 4). A one-way classification analysis of variance (ANOVA) test of differences among measures of mean annual total hardness, 1979-1981, indicates the values are nonsignificant ($P>0.05$).

The pH values in Site 054 ranged from 7.9-9.5 over the study period with seasonal ranges of similar magnitude occurring in both 1979 and 1981. Seasonal trends during 1979 and 1981 were similar while August – October values from 1980 were not (Figure 5). However, a one-way ANOVA test of differences among measures of mean annual pH, 1979-1981, indicates the values are nonsignificant ($P>0.05$).

Total alkalinity in Site 054 ranged from 90 mg/liter in September 1981 to 205 mg/liter in May 1980, with 98 mg/liter (90-188 mg/liter) during 1981 representing the greatest seasonal variation (Figure 6). A one-way classification ANOVA test of differences among measures of total alkalinity collected 1979-1981 in Site 054 indicates they were significant ($P<0.01$). Tukey's w-procedure (Steel and Torrie 1960) was used to determine if data among all years was significantly different. Results indicate 1979 data differed significantly from both 1980 and 1981 data ($P<0.05$), while 1980 and 1981 data differences were nonsignificant ($P>0.05$).

Secchi disk transparency in Site 054 varied from 75 cm in October 1981 to 310 cm in June 1980, with 177 cm (75-252 cm) during 1981 representing the greatest seasonal variation (Figure 7). One-way classification ANOVA tests of differences among measures of Secchi disk transparency collected 1979-1981 in Site 054 indicates they are significantly different ($P<0.01$).

Applying Tukey's w-procedure to this data indicated 1980 and 1981 values were significantly different ($P<0.01$), 1979 and 1980 values were significant ($P<0.05$) and 1979 and 1981 data were nonsignificant ($P>0.05$).

Surface coverage and species composition of aquatic vegetation in Site 054 during 1979-1981 is presented in Table 26. Coontail (*Ceratophyllum demersum*) was the dominant species throughout the study, however, it covered less than 10% of the pond in 1981 while slender najas (*Najas flexilis*) undetected in 1979 and less than 4% in 1980, increased to nearly 9%. Concurrently, drought conditions and associated evaporation gradually reduced Site 054's water volume to 60% of capacity by late 1981.

	1979						1980						1981						Total					
	Freq. of Occurrence		By Number		By Weight		Freq. of Occurrence		By Number		By Weight		Freq. of Occurrence		By Number		By Weight		Freq. of Occurrence		By Number		By Weight	
	No.	%	No.	%	Grams	%	No.	%	No.	%	Grams	%	No.	%	No.	%	Grams	%	No.	%	No.	%	Grams	%
Insecta	31	100.0	439	2.9	0.71	15.9	28	100.0	735	2.2	0.47	4.7							59	100.0	1174	2.4	1.18	8.2
Ephemeroptera	14	45.2	71	0.5	0.09	2.0	25	89.3	242	0.7	0.30	3.1							39	66.1	313	0.6	0.39	2.7
Baetidae	14	45.2	71	0.5	0.09	2.0	25	89.3	231	0.7	0.29	2.9							39	66.1	302	0.6	0.38	2.6
Caenidae							25	89.3	11	0.0	0.01	0.1							25	42.4	11	0.0	0.01	0.1
Odonata	15	48.4	57	0.4	0.28	6.3													15	25.4	57	0.1	0.28	2.0
Anisoptera																								
Aeshnidae	14	45.2	13	0.1	0.10	2.3													14	23.7	13	0.0	0.10	0.7
Zygoptera																								
Coenagriidae	7	22.6	4	0.3	0.18	3.9													7	11.9	44	0.1	0.18	1.2
Diptera	23	74.2	237	1.6	0.09	2.0	3	10.7	493	1.5	0.17	1.7							26	44.1	730	1.5	0.25	1.8
Chironomidae	23	74.2	237	1.6	0.09	2.0	3	10.7	380	1.1	0.14	1.4							26	44.1	617	1.3	0.23	1.6
Culicidae							3	10.7	36	0.1	0.02	0.2							3	5.1	36	0.1	0.02	0.1
Ceratopogonidae							3	10.7	77	0.2	0.01	0.1							3	5.1	77	0.2	0.01	0.1
Coleoptera	7	22.6	52	0.3	0.08	1.9													7	11.9	52	0.1	0.08	0.6
Dytiscidae	7	22.6	10	0.1	0.00	0.0													7	11.9	10	0.0	0.00	0.0
Haliplidae	6	19.4	42	0.3	0.08	1.9													6	10.2	42	0.1	0.08	0.6
Hemiptera	14	45.2	22	0.1	0.17	3.8													14	23.7	22	0.0	0.17	1.2
Saldidae	14	45.2	22	0.1	0.17	3.8													14	23.7	22	0.0	0.17	1.2
Crustacea	31	100.0	14445	96.8	3.50	78.6	28	100.0	32876	97.7	9.08	91.8							59	100.0	47321	97.4	12.58	87.7
Amphipoda	23	74.2	189	1.3	0.18	4.0													23	39.0	189	0.4	0.18	1.2
Gammaridae	23	74.2	189	1.3	0.18	4.0													23	39.0	189	0.4	0.18	1.2
Cladocera	31	100.0	13123	87.9	3.27	73.6	28	100.0	29437	87.5	8.71	88.1							59	100.0	42560	87.6	11.99	83.6
Daphnidae	15	48.4	4094	27.4	3.19	71.7	28	100.0	10432	31.0	8.14	82.3							43	72.9	14526	29.9	11.33	79.0
Bosminidae	23	74.2	8944	59.9	0.01	0.3	28	100.0	18192	54.1	0.03	0.3							51	86.4	27136	55.9	0.05	0.3
Copepoda	31	100.0	1043	7.0	0.02	0.5	28	100.0	2386	7.1	0.09	0.9							59	100.0	3429	7.1	0.11	0.8
Calanoida	16	51.6	120	0.8	0.00	0.1	28	100.0	1159	3.4	0.03	0.3							44	74.6	1279	2.6	0.03	0.2
Cyclopoida							28	100.0	1227	3.6	0.07	0.7							28	47.5	1227	2.5	0.07	0.5
Podocopa	8	25.8	90	0.6	0.02	0.5	25	89.3	1053	3.1	0.28	2.8							33	55.9	1143	2.4	0.30	2.1
Molluska							3	10.7	35	0.1	0.34	3.5							3	5.1	35	0.1	0.34	2.4
Gastropoda							3	10.7	22	0.1	0.19	2.0							3	5.1	22	0.0	0.19	1.4
Pelecypoda							3	10.7	13	0.0	0.15	1.5							3	5.1	13	0.0	0.15	1.0
Sphaeriidae							3	10.7	13	0.0	0.15	1.5							3	5.1	13	0.0	0.15	1.0
Annelida	6	19.4	24	0.2	0.18	4.0													6	10.2	24	0.0	0.18	1.2
Hirudinea	6	19.4	24	0.2	0.18	4.0													6	10.2	24	0.0	0.18	1.2
Detritus	1	3.2	22	0.1	0.07	1.5													1	1.7	22	0.0	0.07	0.5

Table 21. Food items found in 50-99 mm lake chubsuckers from Site 054 during 1979-1980.

	1979						1980						1981						Total					
	Freq. of Occurrence		By Number		By Weight		Freq. of Occurrence		By Number		By Weight		Freq. of Occurrence		By Number		By Weight		Freq. of Occurrence		By Number		By Weight	
	No.	%	No.	%	Grams	%	No.	%	No.	%	Grams	%	No.	%	No.	%	Grams	%	No.	%	No.	%	Grams	%
Insecta							4	100.0	642	31.5	0.27	16.8	49	100.0	7344	40.8	3.41	20.6	53	100.0	7986	39.9	3.68	20.3
Ephemeroptera							4	100.0	24	1.2	0.03	1.9	23	46.9	489	2.7	0.62	3.7	27	50.9	513	2.6	0.65	3.6
Baetidae							4	100.0	24	1.2	0.03	1.9	23	46.9	489	2.7	0.62	3.7	27	50.9	513	2.6	0.65	3.6
Odonata													7	14.3	16	0.1	0.05	0.3	7	13.2	16	0.1	0.05	0.3
Zygoptera																								
Coenagriidae													7	14.3	16	0.1	0.05	0.3	7	13.2	16	0.1	0.05	0.3
Diptera							5	100.0	618	30.3	0.24	15.0	49	100.0	6839	38.0	2.74	16.6	53	100.0	7457	37.2	2.98	16.4
Chironomidae							4	100.0	434	21.3	0.16	9.9	49	100.0	3601	20.0	1.33	8.0	53	100.0	4035	20.1	1.49	8.2
Culicidae													22	44.9	118	0.7	0.06	0.3	22	41.5	118	0.6	0.06	0.3
Ceratopogonidae													18	36.7	78	0.4	0.01	0.1	18	34.0	78	0.4	0.01	0.0
Crustacea							4	100.0	1356	66.5	0.88	54.3	49	100.0	9787	54.4	3.34	20.2	53	100.0	11143	55.6	4.21	23.2
Amphipoda													9	18.4	81	0.5	0.08	0.5	9	17.0	81	0.4	0.08	0.4
Gammaridae													9	18.4	81	0.5	0.08	0.5	9	17.0	81	0.4	0.08	0.4
Cladocera							4	100.0	1113	54.6	0.87	53.8	28	57.1	3764	20.9	2.92	17.6	32	60.4	4877	24.3	3.78	20.8
Daphnidae							4	100.0	1113	54.6	0.87	53.8	28	57.1	3588	19.9	2.80	16.9	32	60.4	4701	23.5	3.67	20.2
Copepoda							4	100.0	243	11.9	0.01	0.5	46	93.9	5420	30.1	0.21	1.3	50	94.3	5663	28.3	0.22	1.2
Calanoida							4	100.0	155	7.6	0.00	0.2	46	93.9	2466	13.7	0.05	0.3	50	94.3	2621	13.1	0.06	0.3
Cyclopoida							4	100.0	88	4.3	0.00	0.3	46	93.9	2954	16.4	0.16	1.0	50	94.3	3042	15.2	0.16	0.9
Podocopa													15	30.6	522	2.9	0.14	0.8	15	28.3	522	2.6	0.14	0.8
Molluska							4	100.0	41	2.0	0.46	28.8	20	40.8	864	4.8	9.79	59.2	24	45.3	905	4.5	10.26	56.5
Pelecypoda							4	100.0	41	2.0	0.46	28.8	20	40.8	864	4.8	9.79	59.2	24	45.3	905	4.5	10.26	56.5
Sphaeriidae							4	100.0	41	2.0	0.46	28.8	20	40.8	864	4.8	9.79	59.2	24	45.3	905	4.5	10.26	56.5

Table 22. Food items found in 100-149 mm lake chubsuckers from Site 054 during 1980-1981.

	1979						1980						1981						Total					
	Freq. of Occurrence		By Number		By Weight		Freq. of Occurrence		By Number		By Weight		Freq. of Occurrence		By Number		By Weight		Freq. of Occurrence		By Number		By Weight	
	No.	%	No.	%	Grams	%	No.	%	No.	%	Grams	%	No.	%	No.	%	Grams	%	No.	%	No.	%	Grams	%
Insecta	2	100.0	500	5.6	1.10	4.4	5	100.0	1725	5.3	6.23	13.0	2	100.0	8	5.9	0.01	11.3	9	100.0	2233	5.4	7.34	10.0
Ephemeroptera							5	100.0	65	0.2	0.08	0.2							5	55.6	65	0.2	0.08	0.1
Baetidae							5	100.0	65	0.2	0.08	0.2							5	55.6	65	0.2	0.08	0.1
Odonata	2	100.0	100	1.1	0.34	1.4	5	100.0	280	0.9	5.35	11.2							7	77.8	380	0.9	5.69	7.8
Anisoptera																								
Libellulidae							5	100.0	145	0.4	4.81	10.0							5	55.6	145	0.4	4.81	6.6
Zygoptera																								
Coenagriidae	2	100.0	100	1.1	0.34	1.4	5	100.0	135	0.4	0.54	1.1							7	77.8	235	0.6	0.88	1.2
Diptera	2	100.0	264	3.0	0.07	0.3	5	100.0	845	2.6	0.32	0.7							7	77.8	1109	2.7	0.40	0.5
Chironomidae	2	100.0	160	1.8	0.06	0.2	5	100.0	545	1.7	0.20	0.4							7	77.8	705	1.7	0.26	0.4
Simulidae							5	100.0	35	0.1	0.01	0.0							5	55.6	35	0.1	0.01	0.0
Chaoboridae	2	100.0	20	0.2	0.01	0.0	5	100.0	200	0.6	0.11	0.2							7	77.8	220	0.5	0.12	0.2
Ceratopogonidae	2	100.0	84	0.9	0.00	0.0	5	100.0	65	0.2	0.01	0.0							7	77.8	149	0.4	0.01	0.0
Coleoptera	2	100.0	70	0.8	0.14	0.6	5	100.0	480	1.5	0.02	0.0	2	100.0	8	5.9	0.01	11.3	9	100.0	558	1.3	0.17	0.2
Chrysomelidae													2	100.0	6	4.4	0.01	6.8	2	22.2	6	0.0	0.01	0.0
Dytiscidae							5	100.0	480	1.5	0.02	0.0							5	55.6	480	1.2	0.02	0.0
Haliplidae	2	100.0	70	0.8	0.14	0.6							2	100.0	2	1.5	0.00	4.5	4	44.4	72	0.2	0.14	0.2
Hemiptera	2	100.0	66	0.7	0.55	2.2	5	100.0	55	0.2	0.45	0.9							7	77.8	121	0.3	1.00	1.4
Corixidae	2	100.0	66	0.7	0.55	2.2	5	100.0	55	0.2	0.45	0.9							7	77.8	121	0.3	1.00	1.4
Crustacea	2	100.0	6080	68.6	0.01	0.0	5	100.0	26580	82.2	5.57	11.6	2	100.0	128	94.1	0.08	88.7	9	100.0	32788	79.3	5.66	7.7
Amphipoda													2	100.0	2	1.5	0.00	2.1	2	22.2	2	0.0	0.00	0.0
Gammaridae													2	100.0	2	1.5	0.00	2.1	2	22.2	2	0.0	0.00	0.0
Cladocera	2	100.0	6080	68.6	0.01	0.0	5	100.0	16580	51.2	4.12	8.6	2	100.0	114	83.8	0.08	85.8	9	100.0	22774	55.1	4.21	5.8
Daphnidae							5	100.0	5260	16.3	4.10	8.6	2	100.0	94	69.1	0.07	82.8	7	77.8	5354	12.9	4.18	5.7
Bosminidae	2	100.0	6080	68.6	0.01	0.0	5	100.0	11320	35.0	0.02	0.0	2	100.0	16	11.8	0.00	0.0	9	100.0	17416	42.1	0.03	0.0
Copepoda							5	100.0	5270	16.3	0.21	0.4	2	100.0	12	8.8	0.00	0.7	7	77.8	5282	12.8	0.21	0.3
Calanoida							5	100.0	2325	7.2	0.05	0.1							5	55.6	2325	5.6	0.05	0.1
Cyclopoida							5	100.0	2945	9.1	0.16	0.3	2	100.0	11	8.8	0.00	0.7	7	77.8	2957	7.2	0.16	0.2
Podocopa							5	100.0	4730	14.6	1.24	2.6							5	55.6	4730	11.4	1.24	1.7
Molluska	2	100.0	2280	25.7	23.94	95.6	5	100.0	4049	12.5	36.14	75.4							7	77.8	6329	15.3	60.09	82.2
Gastropoda	2	100.0	760	8.6	6.71	26.8	5	100.0	3889	12.0	34.34	71.6							7	77.8	4640	11.2	41.05	56.2
Pelecypoda	2	100.0	1520	17.2	17.23	68.8	5	100.0	160	0.5	1.81	3.8							7	77.8	1680	4.1	19.04	26.1
Sphaeriidae	2	100.0	1520	17.2	17.23	68.8	5	100.0	160	0.5	1.81	3.8							7	77.8	1680	4.1	19.04	26.1

Table 23. Food items found in 150-199 mm lake chubsuckers from Site 054 during 1979-1981.

	1979						1980						1981						Total					
	Freq. of Occurrence		By Number		By Weight		Freq. of Occurrence		By Number		By Weight		Freq. of Occurrence		By Number		By Weight		Freq. of Occurrence		By Number		By Weight	
	No.	%	No.	%	Grams	%	No.	%	No.	%	Grams	%	No.	%	No.	%	Grams	%	No.	%	No.	%	Grams	%
Insecta	3	100.0	94	7.4	0.22	56.4													3	100.0	94	7.4	0.22	56.4
Ephemeroptera	2	66.7	8	0.6	0.01	2.6													2	66.7	8	0.6	0.01	2.6
Baetidae	2	66.7	8	0.6	0.01	2.6													2	66.7	8	0.6	0.01	2.6
Odonata	2	66.7	30	2.3	0.13	33.5													2	66.7	30	2.3	0.13	33.5
Anisoptera																								
Aeshnidae	2	66.7	2	0.2	0.02	4.2													2	66.7	2	0.2	0.02	4.2
Zygoptera																								
Coenagriidae	2	66.7	28	2.2	0.11	29.3													2	66.7	28	2.2	0.11	29.3
Diptera	1	33.3	20	1.6	0.01	1.4													1	33.3	20	1.6	0.01	1.4
Chironomidae	1	33.3	10	0.8	0.00	1.0													1	33.3	10	0.8	0.00	1.0
Chaoboridae	1	33.3	1	0.1	0.00	0.1													1	33.3	1	0.1	0.00	0.1
Ceratopogonidae	1	33.3	9	0.7	0.00	0.3													1	33.3	9	0.7	0.00	0.3
Coleoptera	2	66.7	34	2.7	0.06	14.6													2	66.7	34	2.7	0.06	14.6
Dytiscidae	2	66.7	6	0.5	0.00	0.1													2	66.7	6	0.5	0.00	0.1
Haliplidae	2	66.7	28	2.2	0.06	14.5													2	66.7	28	2.2	0.06	14.5
Hemiptera	1	33.3	2	0.2	0.02	4.3													1	33.3	2	0.2	0.02	4.3
Corixidae	1	33.3	2	0.2	0.02	4.3													1	33.3	2	0.2	0.02	4.3
Crustacea	3	100.0	1182	92.5	0.15	39.7													3	100.0	1182	92.5	0.15	39.7
Amphipoda	3	100.0	48	3.8	0.05	11.8													3	100.0	48	3.8	0.05	11.8
Gammaridae	3	100.0	48	3.8	0.05	11.8													3	100.0	48	3.8	0.05	11.8
Cladocera	3	100.0	898	70.3	0.09	24.0													3	100.0	898	70.3	0.09	24.0
Daphnidae	3	100.0	116	9.1	0.09	23.7													3	100.0	116	9.1	0.09	23.7
Bosminidae	2	66.7	782	61.2	0.00	0.3													2	66.7	782	61.2	0.00	0.3
Copepoda	3	100.0	196	15.3	0.00	1.1													3	100.0	196	15.3	0.00	1.1
Calanoida	2	66.7	112	8.8	0.00	0.6													2	66.7	112	8.8	0.00	0.6
Podocopa	1	33.3	40	3.1	0.01	2.8													1	33.3	40	3.1	0.01	2.8
Annelida	2	66.7	2	0.2	0.01	3.9													2	66.7	2	0.2	0.01	3.9
Hirudinea	2	66.7	2	0.2	0.01	3.9													2	66.7	2	0.2	0.01	3.9

Table 24. Food items found in 200-249 mm lake chubsuckers from Site 054 during 1979.

	150-199 mm						250-299 mm						300-349 mm					
	Freq. of Occurrence No.	%	By Number No.	%	By Weight Grams	%	Freq. of Occurrence No.	%	By Number No.	%	By Weight Grams	%	Freq. of Occurrence No.	%	By Number No.	%	By Weight Grams	%
Crustacea	1	100.0	114	87.0	0.09	74.7												
Cladocera	1	100.0	114	87.0	0.09	74.7												
Daphnidae	1	100.0	114	87.0	0.09	74.7												
Insecta	1	100.0	17	13.0	0.03	25.3	1	33.3	12	85.7	0.37	27.5	2	100.0	10	50.0	0.13	23.0
Ephemeroptera	1	100.0	13	9.9	0.02	13.7							1	50.0	1	5.0	0.00	0.2
Baetidae	1	100.0	13	9.9	0.02	13.7							1	50.0	1	5.0	0.00	0.2
Odonata	1	100.0	4	3.1	0.01	11.5	1	33.3	11	78.6	0.36	27.0	1	50.0	4	20.0	0.13	22.8
Anisoptera							1	33.3	11	78.6	0.36	27.0	1	50.0	4	20.0	0.13	22.8
Libellulidae							1	33.3	11	78.6	0.36	27.0	1	50.0	4	20.0	0.13	22.8
Zygoptera	1	100.0	4	3.1	0.01	11.5												
Coenagriidae	1	100.0	4	3.1	0.01	11.5												
Coleoptera													1	50.0	5	25.0	0.00	0.0
Dytiscidae													1	50.0	5	25.0	0.00	0.0
Hemiptera							1	33.3	1	7.1	0.01	0.5						
Corixidae																		
Gerridae							1	33.3	1	7.1	0.01	0.5						
Osteichthyes							2	66.7	2	14.3	0.98	72.5	2	100.0	10	50.0	0.45	77.0
Acanthopterygii							1	33.3	1	7.1	0.36	26.4						
Centrarchidae							1	33.3	1	7.1	0.36	26.4						
Micropterus salmoides							1	33.3	1	7.1	0.36	26.4						
Ostariophysii							1	33.3	1	7.1	0.62	46.1	2	100.0	10	50.0	0.45	77.0
Catostomidae							1	33.3	1	7.1	0.62	46.1	2	100.0	10	50.0	0.45	77.0
Erimyzon sucetta							1	33.3	1	7.1	0.62	46.1	2	100.0	10	50.0	0.45	77.0

	350-399 mm						400-449 mm						500-549 mm					
	Freq. of Occurrence No.	%	By Number No.	%	By Weight Grams	%	Freq. of Occurrence No.	%	By Number No.	%	By Weight Grams	%	Freq. of Occurrence No.	%	By Number No.	%	By Weight Grams	%
Crustacea																		
Cladocera																		
Daphnidae																		
Insecta	2	100.0	7	77.8	0.11	14.1	1	50.0	1	16.7	0.03	3.6	1	50.0	2	9.1	0.54	67.9
Ephemeroptera																		
Baetidae																		
Odonata	1	50.0	2	22.2	0.07	8.7	1	50.0	1	16.7	0.03	3.6	1	50.0	2	9.1	0.54	67.9
Anisoptera	1	50.0	2	22.2	0.07	8.7	1	50.0	1	16.7	0.03	3.6	1	50.0	2	9.1	0.54	67.9
Libellulidae	1	50.0	2	22.2	0.07	8.7	1	50.0	1	16.7	0.03	3.6	1	50.0	2	9.1	0.54	67.9
Zygoptera																		
Coenagriidae																		
Coleoptera																		
Dytiscidae																		
Hemiptera	1	50.0	5	55.6	0.04	5.4												
Corixidae	1	50.0	5	55.6	0.04	5.4												
Gerridae																		
Osteichthyes	2	100.0	2	22.2	0.66	85.9	2	100.0	5	83.3	0.90	96.4	2	100.0	20	90.9	0.26	32.1
Acanthopterygii	2	100.0	2	22.2	0.66	85.9	1	50.0	1	16.7	0.51	54.7	2	100.0	20	90.9	0.26	32.1
Centrarchidae	2	100.0	2	22.2	0.66	85.9	1	50.0	1	16.7	0.51	54.7	2	100.0	20	90.9	0.26	32.1
Micropterus salmoides	2	100.0	2	22.2	0.66	85.9	1	50.0	1	16.7	0.51	54.7	2	100.0	20	90.9	0.26	32.1
Ostariophysii							1	50.0	4	66.7	0.39	41.7						
Catostomidae							1	50.0	4	66.7	0.39	41.7						
Erimyzon sucetta							1	50.0	4	66.7	0.39	41.7						

Table 25. Food items found in northern pike from Site 054 during 1980.

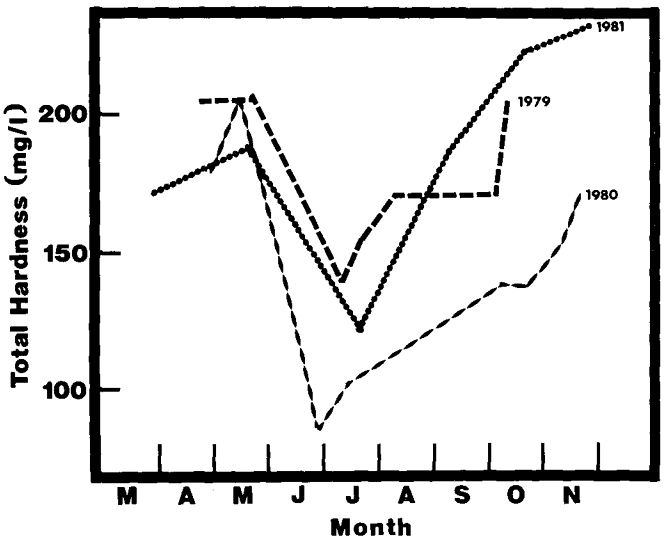

Figure 4. Seasonal changes in total hardness (mg/liter) during 1979-1981 in Site 054.

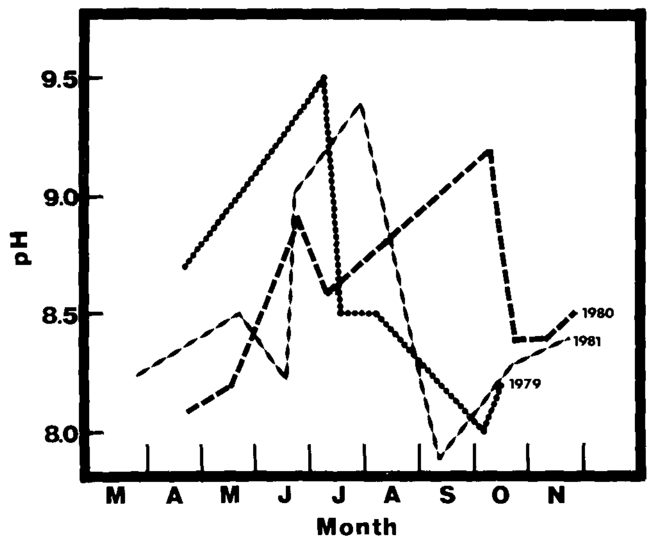

Figure 5. Seasonal changes in pH during 1979-1981 in Site 054.

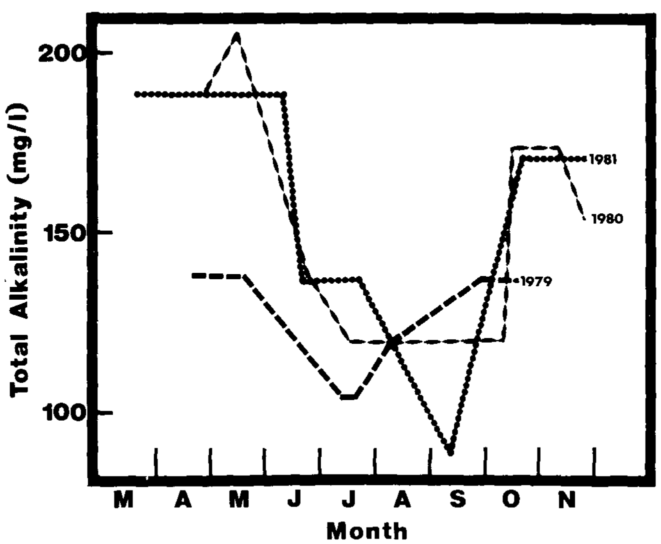

Figure 6. Seasonal changes in total alkalinity (mg/liter) during 1979-1981 in Site 054.

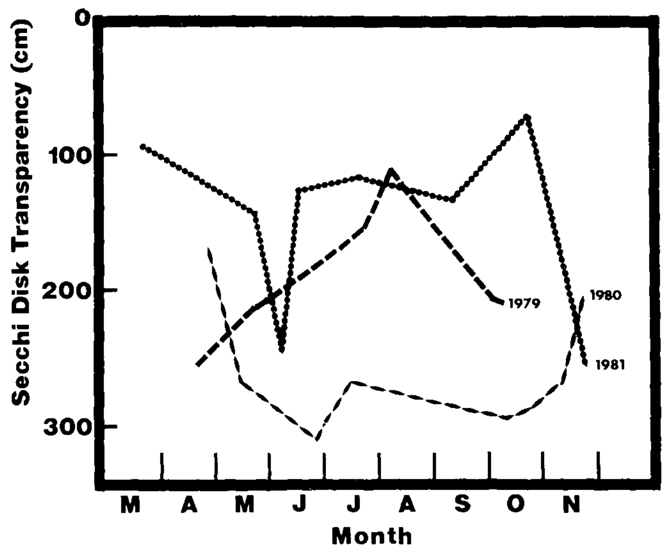

Figure 7. Seasonal changes in Secchi disk transparency (cm) during 1979-1981 in Site 054.

Species	1979	1980	1981
Ceratophyllum demersum	56.98%	26.05%	9.84%
Najas flexilis		3.89%	8.63%
Typha spp.	2.72%	2.04%	2.91%
Potamogeton	1.12%	1.13%	2.44%
P. pectinatus	<1.00%	<1.00%	2.07%
P. pusillus	<1.00%	<1.00%	<1.00%
P. nodosus	<1.00%	<1.00%	<1.00%
Sagittaria spp.	<1.00%	<1.00%	<1.00%
Lemna minor	<1.00%	<1.00%	<1.00%
Total	61.82%	33.12%	23.85%

Table 26. Percent surface coverage and species composition of aquatic vegatation during 1979-1981 in Site 054.

DISCUSSION

An optimum forage species is defined by Bennett and Childers (1966) to have: 1) the capability of growing larger than the size range for predation by the larger individuals of the carnivorous species; 2) an abundance of young at a time when these young will be available as food for the young of the carnivores; 3) round bodies and soft-rayed fins which are more acceptable as food than laterally compressed, spiny-rayed species; 4) the capability of maintaining a population of adults when stocked in combination with a dominant population of carnivores; 5) no preference for eggs or young of the carnivores or competition with them for food or habitat; and 6) no capabilities of changing the physical or biological characteristics of the fish habitat. Several of these criteria were used to evaluate the potential of the lake chubsucker as forage for largemouth bass.

Age and growth data were used to establish growth rates and maximum size the lake chubsucker can attain in Nebraska waters. Estimates of sizes of various forage fishes largemouth bass can swallow were applied with the growth data (Lawrence 1958). Together they provided insight into the lake chubsucker's capability of growing larger than the size range for predation by the larger piscivorous largemouth bass, as well as the lake chubsucker's vulnerability at various sizes to predation by the various sizes of largemouth bass.

Nine lake chubsuckers longer than 250 mm were sampled. A 295 mm, age 4 individual represents the maximum known size this species has currently attained in Nebraska waters (Table 4). However, since at least eight of these fish were produced prior to 1979, their initial growth occurred in Indiana waters. Testing backcalculated length at age 1 of these fish with Nebraska spawned lake chubsuckers (Table 5) failed to show a significant difference in growth (t-test, $P>0.05$). It was therefore concluded that lake chubsuckers grown entirely in Nebraska will attain similar lengths.

Lawrence (1958) determined that a largemouth bass would readily swallow a forage fish whose maximum body height was equal to the mouth width of the largemouth bass, providing the maximum height of the forage fish's body was much greater than its maximum width. This measure was used to evaluate the lake chubsucker's capability of growing larger than the size which largemouth bass could consume. However, the height:width provision first had to be met. The absence of specified standards required an alternate method for determining lake chubsucker qualification. Since largemouth bass were included as prey in Lawrence's analysis, it seemed reasonable to assume that if their height:width ratios did not differ significantly from the lake chubsuckers, over the same range of total lengths, then the lake chubsucker could be used. Lawrence's largemouth bass data do not provide these ratios, however, if his findings are to receive widespread application they must be representative of largemouth bass in Nebraska waters as well. Considering this it seemed rational to use largemouth bass from Site 054 for the ratio measurements. Maximum height, maximum width and total length were measured to the nearest millimeter on 18 largemouth bass and lake chubsuckers during 1981. The mean calculated lake chubsucker height: width ratio of 1.89 (1.77 - 1.96) was not significantly different (t-test, $P> 0.05$) than the corresponding largemouth bass ratio of 1.93 (1.87 - 2.08). This was interpreted as allowing use of Lawrence's data for analysis purposes (Table 27).

Particularly important is the estimated 450+ mm largemouth bass needed in order to consume a 241 mm lake chubsucker. Furthermore the 295 mm lake chubsucker would require a largemouth bass longer than 540 mm. Since largemouth bass in Nebraska are capable of reaching these lengths in small impoundments, (<200 hectares) it appears the lake chubsucker is unable to outgrow predation by big largemouth bass. Lake chubsuckers may be able to maintain a population of adults however, since only a small number of largemouth bass reach 465 mm.

Lawrence (1958) calculated mean weight for each length of forage fish described in his paper. Contrasting mean weights of bluegill, the most commonly stocked forage fish for largemouth bass, with those of lake chubsuckers possessing equivalent heights, emphasizes the potential value of the lake chubsucker. For each bluegill a largemouth bass of a given size can swallow, that same largemouth bass can swallow a lake chubsucker weighing 48.8 - 177.8% more.

Evaluation of the lake chubsucker's ability to produce an abundance of young at a time when they would be

Largemouth Bass[1] Total Length (mm)	Largemouth Bass[1] Mouth Width[2] (mm)	Lake Chubsucker Total Length (mm)
50	6	39
75	8	46
100	9	51
125	12	61
150	15	72
175	18	82
200	21	93
225	24	110
250	27	121
275	30	132
300	33	141
325	37	153
350	40	164
375	43	176
400	49	195
425	54	227
450	59	241
475	64	255
500	67	265
525	74	283
550	80	300

[1]These calculations are based on Lawrence's equations for estimating mouth widths of largemouth bass.

[2]These values also represent the mean maximum depths of body for each corresponding chubsucker's length.

Table 27. Estimated sizes of lake chubsuckers which largemouth bass can swallow.

available as prey for young largemouth bass was accomplished by identifying the lake chubsucker's age at maturity, size at maturity, spawning season and fecundity.

Examination of 142 female lake chubsuckers collected from Site 059 during the 1981 spawning season indicated all became sexually mature by 100 mm (age 1), with the smallest becoming sexually mature at 63 mm (Table 11). Cooper (1935) found that both sexes reached maturity at age 2 with a mean total length of nearly 127 mm in Michigan waters. The disparity between the female's ages at first maturity may be demonstrating the significance of size. The Michigan fish reached 75 mm at age 1, a length at which less than 43% of the Site 059 lake chubsuckers were sexually mature (Table 11), while the 1980 year class from Site 059 reached 100 mm at age 1 (Table 7). Whether the lake chubsucker can be expected to reproduce at age 1 in Nebraska waters may well depend on its growth. Considering the diverse lengths at age 1 between the 1979 and 1980 lake chubsuckers in Site 059 (Table 7), and the Site 059 1980 year class and all Site 054 year classes at age 1 (Table 4), it is doubtful the lake chubsucker will consistently reach 100 mm by age 1.

Whether the lake chubsucker is prolific depends on one's definition of the term. Since the bluegill is the forage fish most commonly stocked with largemouth bass, the lake chubsucker's fecundity will be compared against that of the bluegill.

Bluegills 102-126 and 127-151 mm average 6,787 and 12,398 ova per individual, respectively (Carlander 1977), while lake chubsuckers average 4,555 and 5,890 ova within comparable length ranges (Table 10). This represents 49-80% less fecundity by the lake chubsucker, suggesting they are considerably less prolific. Further, since there is no evidence of parental care by lake chubsuckers; there is no reason to expect superior survival of the eggs or fry.

Kramer and Smith (1960) stated that angler catch of largemouth bass is often influenced by year class strength and it is generally assumed that the numerical strength of individual year classes is determined during the first growing season. If this assumption is valid, then the abundance of usable food during the first growing season may affect the survival rate and hence the availability of largemouth bass to the angler. Since largemouth bass can become piscivorous at 30 mm (Kramer and Smith 1960), an abundance of appropriately sized age 0 lake chubsuckers at a suitable time could have a positive effect on the largemouth bass survival rate. However, Kramer and Smith frequently found low utilization of forage fish by age 0 largemouth bass and attributed this to the fact that many forage fish spawned at the same time as the largemouth bass, producing young that grew at the same rate as the largemouth bass and were therefore unavailable as food. In the present study fish first appeared in the diet of 150-199 mm largemouth.

Largemouth bass begin spawning 2-5 days after mean water temperature reaches and remains above 15.6 C (Kramer and Smith 1960). The free swimming, foraging fry generally appear 312 hours (13 days) after egg deposition when water temperatures are 18-20 C (Laurence 1969). Using continuously recorded water temperatures taken 30 cm below surface and applying Kramer and Smith's (1960) data, the Site 054 largemouth bass were estimated to have spawned during the week of 11 May 1981. Five largemouth bass fry (18 $\pm$ 1.58 mm) were collected on 12 June. Kramer and Smith (1960) found that largemouth bass fry were approximately 6 mm at the beginning of the free swimming, foraging stage and grew 0.5 mm per day for the first several weeks. Using existing data to backcalculate, (Kramer and Smith 1960; Laurence 1969), the Site 054 largemouth bass reached the free swimming, forage stage on 20 May, placing fertilization on 7 May, 13 days earlier. Although this estimate is four days prior to that based on mean water temperatures, enough variability in daily growth can be found in Kramer and Smith's (1960) data to accept the 11 May date.

Lake chubsucker spawning in Site 059, as indicated by GSI values, extended from the week of 24 April through the week of 5 June (Figure 3). Peak spawning, recognized by the sharp decline in GSI and the presence of spent ovaries on 5 June, lasted two weeks beginning 21 May (Figure 3). Confirmation of these estimates was made possible with the collection of 12 lake chubsucker fry averaging 15.7 $\pm$ 1.44 mm on 12 June 1981. Scott and Crossman (1973) indicate lake chubsucker eggs hatch in 6-7 days at 22.2-29.4 C. Fry, on hatching, are 6-7 mm and grow 0.5 mm per day for the first month in Michigan waters (Scott and Crossman 1973). Assuming these growth patterns are characteristic of lake chubsuckers in Nebraska, hatching of the sampled fry occurred on 27 May with prior fertilization on 21 May 1981.

Thermographs indicate a given water temperature in Site 059 was reached approximately four days sooner in Site 054 throughout the sample period. It was assumed this phenomenon manifested itself in the timing of the lake chubsucker spawning as well. Consequently the lake chubsucker spawn in Site 054 theoretically occurred between 20 March and 8 June, with the peak between 17 May and 8 June, 1981. With largemouth bass spawning after 7 May, simultaneous spawning to some degree is probable, although age 0 lake chubsuckers were never sampled or observed in Site 054 during 1981. Carr (1942) observed lake chubsuckers laying their eggs in largemouth bass nests. This would require simultaneous spawning, consistent with estimates from Site 054. Simultaneous spawning dates can be further confirmed by the presence on 12 June of 16 mm lake chubsuckers in Site 059 and 18 mm largemouth bass in Site 054.

Comparisons of growth to age 1 for each species indicates insufficient differences to allow predation by the largemouth bass on lake chubsuckers. The 1980 year class of largemouth bass in Site 054 reached 82 mm by age 1, (Table 2) requiring lake chubsuckers smaller than 47.7 mm as forage (Table 27). By contrast the 1980 year class of lake chubsuckers in Site 054 reached 62 mm by age 1 (Table 5). It is possible that 62 mm may represent the mean length of those individuals which escaped predation. There is considerable evidence that during the first year of life slower growing individuals are more susceptible to predation (Jones 1958), however lake chubsuckers were never found in the diet of age 0 (<100 mm) largemouth bass (Tables 15-16). The data indicate the phenomenon to which Kramer and Smith (1960) allude, low utilization of forage fish by age 0 largemouth bass due to simultaneous spawning and similar growth rates, took place.

Determining preference for lake chubsuckers over spiny rayed, laterally compressed fishes (e.g. bluegill) was not made since the largemouth bass' own progeny represented their only source of spiny rayed forage. While cannibalism is coommon among largemouth bass (Kramer and Smith 1962; Zweiacker and Summerfelt 1973; Cooper 1937), it was felt this was not a valid comparison since largemouth bass are not commonly managed as forage. Therefore simple acceptability of lake chubsuckers as forage was evaluated by examining a combination of largemouth bass food habits, biomass estimates and age and growth data. Food habits were considered desirable for estimating that portion lake chubsuckers represent of the total largemouth bass diet, a quantitative measure of their utilization by largemouth bass. If lake chubsuckers were a superior forage, this may be reflected as an above average largemouth bass biomass and/or improved growth rates.

As previously discussed, the absence of lake chubsuckers in the diet of age 0 (0-99 mm) largemouth bass (Tables 15-16) is apparently due to simultaneous spawning and similar growth rates. This is supported by the fact that young-of-the-year (YOY) largemouth bass in 1980 had access to large numbers of age 0 lake chubsuckers and yet failed to demonstrate significantly improved growth (t-test. $P>0.05$) over the 1981 YOY which apparently did not have access to age 0 lake chubsuckers (Table 12). Further, neither cannibalism nor predation on age 0 northern pike by this size class was ever documented (Tables 15-16).

The lack of lake chubsuckers in the diet of 150-199 mm largemouth bass (Table 17) likely resulted because largemouth bass of this size were absent in 1980 when lake chubsuckers were apparently most plentiful. This occurred because the 1978 year class of largemouth bass was not sexually mature during 1979, resulting in a missing year class whose individuals would be expected to have been 150-199 mm during 1980. Examination of this size group's diet (Table 17) indicates piscivorous activity occurred as predation on small northern pike and cannibalism in 1979 and 1981, respectively.

The 50-73.3% frequency of occurrence of lake chubsucker fry in the stomachs of 200+ mm largemouth bass (Tables 18-19) indicates largemouth bass contributed significantly to the dramatic decrease in lake chubsucker biomass between the 1980 and 1981 sample estimates. Lake chubsuckers made up 99.4%, 45.5% and 43.9%, by weight, of the 1980 diets of the three larger sizes of largemouth bass (Tables 18-20). Interestingly a 101 mm, age 1 lake chubsucker was sampled from a 300+ mm largemouth bass in 1981 (Table 20), indicating a few lake chubsuckers from the 1980 year class were still present in 1981.

Reynolds and Babb (1978) recommend that a balanced largemouth bass population in a small impoundment have: 1) a biomass of at least 45 kg/hectare; and 2) a growth rate which permits 200 mm largemouth bass to reach quality size (>305 mm) in approximately 1 year. Additional requirements include: 3) at least 49 adults/hectare; 4) moderate annual mortality, no more than 50% for ages 2-5; 5) no missing year classes, ages 0-5; 6) a young:adult ratio (YAR) index of 10:1; and 7) a proportional stock density (PSD) value of 40-60%.

Within the time frame of the study, development of a largemouth bass biomass approaching a stable density was unlikely. Stable density is defined as the tendency for the largemouth bass to remain at a constant biomass.

Based on length frequency data, age and growth data, population estimates, biomass estimates and mortality estimates, the Site 054, 1981 largemouth bass data indicate: 1) a biomass of 58.7 kg/hectare (Table 13); 2) a growth rate allowing 200 mm largemouth bass to reach 295 mm in 1 year (Table 2); 3)58 adults/hectare (Table 13); 4) mortality from age 2 to age 3 of 44.2% (Table 13); 5) one missing year class, 1979 (Table 2); 6) a YAR of 24.5:1 (Table 13); and 7) a PSD of 84.2% (Table 3). That the first four parameters listed seem acceptable while the other population parameters seem unacceptable should be viewed with caution, since most are based on only the 1978 year class. Above average survival of initially stocked largemouth bass was expected since most natural predators were presumed absent, thus inflating the PSD value. However, the missing 1979 year class is suspected of having an equal impact, forming a cause and effect relationship with the high PSD and YAR indices. Assuming growth similar to that of the 1978 year class, the missing 1979 year class would have provided a larger number of 200-304 mm than 305+ mm largemouth bass in 1981, thus reducing the PSD value. Any 305+ mm specimens provided by the missing year class would have also reduced the YAR, but concurrently increased the number of adults/hectare.

Age and growth of the 1978 year class must also be viewed with caution. Back-calculated length at ages 1 and 2 for the 1978 year class were 25 mm and 81 mm longer, respectively, between 1980 and 1981 estimates. The differences in backcalculated lengths were significant (t-test, $P<0.05$), suggesting "Lee's phenomenon" (Ricker 1979) was occurring. Four possible causes have been suggested for the occurrence of Lee's phenomenon: 1) using an incorrect back-calculation procedure; 2) nonrandom sampling of the stock; 3) selective natural mortality, favoring greater survival of smaller fish; and 4) selective fishing mortality, similarly biased. The possibility of this phenomenon being due to the first cause was discarded following backcalculations using four separate methods, Lea (1910; cited by Bagenal and Tesch 1978), Monastrysky (1930; cited by Bagenal and Tesch 1978), Lee (1920; cited by Bagenal and Tesch 1978) and Fraser corrected direct proportion (Fraser 1916), which failed to improve results. Each of the remaining are possibilities, although one would not expect to observe those large differences due to selective natural mortality with such young largemouth bass. Selective fishing mortality is also possible in spite of the lake being closed to fishing since the lake was not constantly patrolled. Nonrandom sampling is the most probable cause since age and growth in 1980 were based on only 13 of an estimated 104 members (12.5%) of the 1978 year class while in 1981 age and growth were based on 48 of an estimated 58 remaining individuals (82.8%) from the 1978 year class.

The 1978 and 1980 largemouth bass year classes must also be dealt with independently when evaluating length at age 1. The 1978 year class of largemouth bass were 102 mm long when stocked, growing an additional 18 mm in Site 054 to age 1 (Table 2). By contrast length at age 1 for the 1980 year class, produced entirely in Site 054, was only 84 mm (Table 2). An additional estimate of first year growth can be made if we assume mean length at capture for the November 1981 sample of the 1981 year class represents length at age 1. A comparison of mean length at capture for the 1980 year class during November 1980 (Table 2) with their back-calculated length at age 1 from the 1981 sample (Table 2) was identical, indicating this is a reasonable assumption. The mean length of the November 1981 sample of 14 age 0 largemouth bass was 87.5 ± 16.5 mm ($\bar{X} \pm SD$). Since 1980 and 1981 growth was achieved entirely within the research pond and the mean lengths were not significantly different (t-test, P>0.05), it seems reasonable to accept these year classes as more representative than those of the 1978 year class. By comparison, Johnson and Zadina (1973) found a mean length of 102 mm at age 1 for largemouth bass from loam bottom, eastern Nebraska waters (Table 28), indicating Site 054 first year growth is less than expected.

The impact of exceptional first year growth on subsequent growth of the 1978 largemouth bass year class is difficult to determine. Nevertheless an increase in length of 79 mm (Table 2) between ages 1 (120 mm) and 2 (199 mm) does represent the result of food consumed in Site 054. Again, an additional estimate of yearling largemouth bass growth can be made by comparing mean length of 1980 year class individuals at capture during the 1981 sample (187 mm) to their backcalculated mean length at age 1 (82 mm) (Table 2). The 105 mm growth increment represents growth of the age 1 individuals during the 1981 season and is significantly larger than the 79 mm found for the 1978 year class during 1979 (t-test, P<0.05). The only observable difference between the diets of age 1 (150-199 mm) largemouth bass in 1979 and 1981 is the preponderance, by weight, of age 0 largemouth bass in the 1981 fish stomachs (Table 17). However, with the small number of stomachs examined both years, substantive conclusions cannot be drawn. Comparatively, Johnson and Zadina (1973) found a mean length of 211 mm at age 2, with a corresponding growth of 109 mm as yearlings (Table 28).

Lake chubsucker biomass estimates were made for November of 1980 and 1981 (Table 12) in an attempt to determine the lake chubsucker's ability to maintain a population in a largemouth bass dominated piscivorous community. Similar to the largemouth bass, lake chubsucker biomass dropped between 1980 and 1981 (Table 12). To understand the relationship between largemouth bass and lake chubsucker biomass, it is important to appreciate caloric intake requirements of the largemouth bass and how this might affect chubsuckers through predation. This can be accomplished using a model presented by Hackney (1975). His model relates interaction of some of the more important factors affecting biomass such as food, assimilation and metabolic efficiency, and mortality.

Carnivorous fish are able to assimilate 80 to 90% of the calories in their food (Winberg 1956), the remainder being lost in the faeces. The lower percentage is more appropriate when ingestion of large quantities of invertebrates occurs, while the higher percentage is more appropriate with high ingestion of fish and soft bodied organisms. Since, by dry weight, a large quantity of the food consumed by adult largemouth bass in Site 054 during 1980 was fish, the upper value of 90% is used. Additional assumptions used by Hackney, and included in this analysis, are that the unitary caloric content of largemouth bass flesh and food is similar, that the food (caloric) requirements for metabolism average 0.5% of the largemouth bass biomass (caloric mass) per day throughout the year, and finally that the total annual largemouth bass mortality rate is 50%.

Applying this model to data of this study, the estimated total assimilated food needed for metabolism in 1980 was 182.5% (0.5% per day x 365 days) of the bass biomass, which calculates to be 173.7 kg/ha/yr (1.825/yr x 95.2 kg/hectare). However, since only 90% of calories consumed are actually assimilated, 193.0 kg/ha/yr of food would be required in order to sustain the 1980 population biomass. Further, since the largemouth bass exhibit 50% total annual mortality, 47.6 kg/hectare of largemouth bass would be replaced annually. Again, at 90% efficiency it would require an additional 52.9 kg/ha/yr be consumed. Consequently the 1980 Site 054 largemouth bass population would hypothetically require 226.6 kg/ha/yr if it is to retain its biomass. Estimates indicate lake chubsuckers were providing 67.5 kg/hectare as forage biomass in November 1980 (Table 12). This would support only 26.1 kg/ha/yr of largemouth bass. Food habits data indicate that largemouth bass fed on an array of different organisms. Nevertheless the loss in largemouth bass biomass to 58.7 kg/hectare in November 1981 indicates an insufficient food supply to meet metabolic needs. The corresponding lake chubsucker biomass diminished to 2.2 kg/hectare by November 1981. Assuming the 65.3 kg/hectare of lake chubsucker biomass lost between 1980 and 1981 was all consumed by largemouth bass and assuming no lake chubsucker biomass was produced and consumed during the same period, lake chubsuckers were capable of supporting 25.3 kg/ hectare of largemouth bass. Since largemouth bass biomass was estimated at 58.7 kg/hectare in November 1981, the remaining 2.2 kg/hectare of lake chubsuckers would then only support 0.8 kg/ha/yr of largemouth bass in 1982. The impact of the piscivorous northern pike on lake chubsucker biomass in 1980 and 1981 cannot be overlooked. The inability to sample sufficient numbers of northern pike prevented biomass estimates and subsequently their caloric intake requirements. Nevertheless northern pike food habits indicate frequent consumption of lake chubsuckers.

While no definite conclusions can be reached, the trend indicates lake chubsuckers will subsequently be reduced to a minor role as forage for largemouth bass. Their ability to maintain a large population in a largemouth bass dominated community is suspect, even in the absence of additional predators such as northern pike.

Lake chubsucker preference for eggs or young of large-

	Year Class								
	I		II		III		IV		V
Mean Length (mm)	101.6		210.8		299.7		375.9		416.6
length increment (mm)		109.2		88.9		76.2		40.7	
Mean Weight (g)	45.4		136.2		363.2		771.8		1225.8
weight increment (g)		90.8		227.0		408.6		454.0	

Table 28. Mean total lengths at age 1-5 for largemouth bass (n = 781) from loam bottom lakes in eastern Nebraska between 1966 and 1972 (Johnson and Zadina 1973).

mouth bass was not directly addressed. Preference is defined as choosing one above another, and testing the lake chubsucker's choice of largemouth bass eggs or young above those of another species was not attempted. However, ingestion of eggs and young was not detectable from lake chubsucker food habits. Largemouth bass eggs or young were never observed in the stomachs of 124 lake chubsuckers examined in this study. This observation is consistent with that of several authors (Ewers and Boesel 1935; Shireman et al. 1978; Scott and Crossman 1973). However, at least one reference (North Carolina Wildlife Resources Commission 1962) indicated lake chubsuckers prefer eggs. Nevertheless considering findings by Carr (1942), and reference by Scott and Crossman (1973), indicating observation of lake chubsuckers spawning in largemouth bass nests actively guarded by a male, it is questionable whether lake chubsuckers would ingest the host's eggs to guard against incidental ingestion of their own eggs. Further the guarding male largemouth bass apparently perceives the lake chubsucker as no threat to his eggs.

Of equal concern is lake chubsucker competition with largemouth bass for food or habitat. Competition is here defined as: use by two or more organisms of a common vital resource which is limited in supply or availability. Establishing competition requires rigorous estimates of various statistical parameters of the populations from which samples are being drawn, consequently it was not attempted. However, quantitative analysis using an overlap index can provide valuable information to this end. The hypothesis that community structure is primarily determined by competition contains implications concerning differences in foraging efficiency between species (Krebs 1978). An assumption of the hypothesis is that species in a community can be arranged along a continuous resource axis such as food, and competition between two species can be measured by the degree of overlap of their utilization function (food overlap). Overlap indices are intended to serve as empirical measures (Horn 1966). They should not be interpreted as estimates of statistical parameters of the populations, but they can alert the user to potential problems such as competition for food. In this study only largemouth bass and lake chubsucker food overlap was examined. Food overlap was expressed as a percentage of the total diet. The index used was (Horn 1966):

$$\hat{C}_\lambda = \frac{2\sum_{i=1}^{S} x_i y_i}{\sum_{i=1}^{S} x_i^2 + \sum_{i=1}^{S} y_i^2}$$

where C_λ is the measure of overlap, ranging from 0% when the diets contain no species in common, to 100% when the samples are identical with respect to percent of species composition; s represents the total number of species in both samples; and x_i and y_i represent proportions of the respective diets composed of the food species i. With classification of the food items occurring at the family level, precision was biased in favor of higher overlap than may have actually occurred. Nevertheless values were low, ranging from 2.09 - 38.92% (Table 29) for size groups common to both species in the samples. Considering the low index values calculated, in

Size of Fish (mm)	Overlap Index (C_λ) by Number of Food Items
50-199	38.92%
150-199	6.51%
200-249	2.09%

Table 29. The degree of commonality (expressed as a percentage) of food items in the diets of lake chubsuckers and largemouth bass 50-99, 150-199 and 200-249 mm total length.

spite of bias favoring high values, there does not appear to be any justification for concern with respect to competition for food.

Bennett and Childers (1966) indicated that an optimum forage fish has no capability of changing the physical or biological characteristics of the fish habitat. Biological characteristics of the fish habitat were interpreted to mean the living components (i.e. the flora and fauna) of the environment in which the fish lives. The mere presence of lake chubsuckers changes the biological characteristics of a pond previously devoid of them. It was therefore questioned whether this criterion could be met by any forage fish. Furthermore forage fish may improve some physical characteristics of the fish habitat, which by definition constitutes a change. It was subsequently determined from comments in Bennett and Childers' (1966), that an optimum forage fish must not have the capability of adversely affecting the physical characteristics or the resident flora and fauna desired in a pond. Physical characteristics that were monitored were water temperature and water transparency while the only biological characteristic monitored was rooted aquatic macrophytes. However the food overlap indices discussed previously also address interaction between the lake chubsuckers and largemouth bass, a component of the biological characteristics of fish habitat. Total alkalinity, total hardness, pH and dissolved oxygen were included since they often reflect biological activity.

Physical, chemical and biological baseline data were not collected prior to initiation of the project, thus preventing assessment of changes due to the project. Analysis of variance of the physical and chemical parameters examined indicate only total alkalinity and Secchi disk transparency changed significantly during the period of study.

In 1979 mean total alkalinity differed significantly from the other years at the 5% level. Inasmuch as lake chubsucker densities were not measured in 1979, hypotheses concerning their effect on total alkalinity are not presented. However, differences in total alkalinity levels were insignificant between 1980 and 1981 in spite of significant differences in population densities. These observations lead to the conclusion that lake chubsuckers did not significantly affect total alkalinity.

Concentrations of suspended substances, organic or inorganic, limit light transmission in water (Reid 1961). Analysis of variance of Secchi disk transparency data indicates 1980 and 1981 values are significant ($P<0.01$) as well as 1979 and 1980 values ($P<0.05$). Noteworthy is the fact that highest measured lake chubsucker density was associated with highest Secchi disk readings, a phenomenon one would not expect if these fish were capable of significantly reducing water transparency. Consistent with this observation, lake chubsuckers are considered clear water species that do not roil the bottom and are highly intolerant of turbidity and siltation (Bennett and Childers 1966; Trautman 1957). This does not preclude the possibility that lake chubsuckers are incapable of altering water transparency however. As an example, food habits analysis from this study indicates a high incidence of zooplankton in the lake chubsucker diets. Since plankton are part of the suspended particulate matter responsible for water's opaqueness, a significant change in their numbers should alter water transparency. One mechanism by which this may be achieved will be discussed with reference to changes in surface coverage of aquatic macrophytes in Site 054.

Estimates of the percent of the pond surface covered by aquatic macrophytes during July of each study year (Table 26) peaked during 1979 (61.8% coverage) with coontail dominating (92.2% of the total), and reached its lowest level during 1981 (23.9% coverage) with coontail and slender najas (41.3% and 36.2% of the total, respectively) dominating. Concurrently lake chubsucker biomass was not estimated in 1979, reached its highest level in 1980 and fell dramatically in 1981. Several authors (Trautman 1957; Bennett and Childers 1966; Scott and Crossman 1973; Pflieger 1975; Mahon and Balon 1977) indicate lake chubsuckers are most frequently found in clear, quiet waters having much submerged aquatic vegetation. Hilderbrand and Schroeder (1927) indicate lake chubsuckers are quite herbivorous, Meehan (1941) observed them controlling *Utricularia spp.* and other types of submerged aquatic vegetation and Shireman et al. (1978) found 100% frequency of filamentous algae occurrence in their diets. Based on this literature, a relationship exists between lake chubsuckers and aquatic vegetation. Since aquatic vegetation, in spite of its abundance, was never detected in the diets of Site 054 lake chubsuckers, it seems reasonable to assume they were not directly affecting aquatic vegetation through grazing. On the other hand, the possibility of an indirect effect exists. A current hypothesis is that planktivorous fishes can significantly alter a zooplankton community's size composition by selectively removing the larger members. This allows many phytoplankton, on which the larger zooplankton have been grazing, to dramatically increase, subsequently reducing macrophytes through shading. Considering the high incidence of zooplankton in the diets of lake chubsuckers the possibility of lake chubsuckers adversely affecting the submerged aquatic macrophytes cannot be ruled out.

SUMMARY AND CONCLUSIONS

Lake chubsuckers are capable of growing larger than the size range for predation by the majority of largemouth bass. This provides lake chubsuckers with a distinct advantage over forage fishes such as fathead minnows (*P. promelas*) since every member of the latter species is vulnerable to predation by most largemouth bass due to the size difference. Apparently only a few lake chubsuckers reach a size large enough to afford nearly complete protection from predation however. On the other hand, lake chubsuckers grow at a rate which makes them vulnerable to a large number of predators for a period of several years. This growth pattern is in contrast with fast growing gizzard shad (*Dorosoma cepedianum*) and common carp (*Cyprinus carpio*) which are normally vulnerable to predation for only a short period of their life time. It is therefore concluded that lake chubsuckers can adequately meet Bennett and Childers' (1966) first criterion (i.e. individual forage fish must be capable of growing larger than the size range for predation by largemouth bass).

This research, and literature citations, indicates lake chubsuckers spawn simultaneous to the largemouth bass. Unfortunately, first year growth of the two species is sufficiently similar to prevent the age 0 largemouth bass from preying on the lake chubsucker. Furthermore lake chubsuckers appear to be considerably less prolific than other forage fish, such as bluegills, which have demonstrated the capability of maintaining a population in a largemouth bass dominated community. It is therefore concluded that lake chubsuckers do not meet Bennett and Childers' (1966) second criterion (i.e. an optimum forage species will have an abundance of young at a time when these young will be available as food for the young of the carnivores).

Lake chubsuckers possess round bodies, however no more so than Site 054 largemouth bass, and soft rayed fins. Bennett and Childers (1966) hypothesized this would allow largemouth bass to consume heavier members (therefore greater calories) of this species than of laterally compressed, spiny rayed species such as bluegills. Application of Lawrence's (1958) research supports this hypothesis. Largemouth bass diets in Site 054 did not support this hypothesis however, due possibly to the small numbers of large lake chubsuckers available. Nevertheless the morphological attributes required by Bennett and Childers (1966) in criterion three are met. The remaining criterion, greater acceptability by largemouth bass, was technically not addressed since cannibalism of small largemouth bass represented the only spiny rayed forage choice. Simple acceptability was established by the presence of lake chubsuckers in the diet of largemouth bass. Above average largemouth bass growth and/or densities were never demonstrated however.

A remnant population of large lake chubsuckers, presumably invulnerable to predation, remained at the end of the study. Reproduction was not documented in 1981, suggesting that lake chubsuckers were either too few to successfully reproduce or their spawn was entirely consumed by predators, of which largemouth bass were undoubtedly most abundant. Diets of largemouth bass examined in 1981 never included age 0 lake chubsuckers however, thus reducing the likelihood of the latter possibility. Climatic conditions were dismissed as factors limiting spawning in Site 054 in 1981 since lake chubsuckers spawned successfully in Site 059 in 1981. The small population of lake chubsuckers may have been a result of added predation from northern pike. However, northern pike were never sampled in sufficient numbers to conduct population estimates and those sampled were small, indicating a considerably lower biomass than that of the largemouth bass. Finally a higher lake chubsucker:largemouth bass stocking ratio may have allowed lake chubsuckers to better establish and maintain their population, however the limited quantity of lake chubsuckers available eliminated this option. Consequently it is concluded that lake chubsuckers have not met Bennett and Childers' (1966) fourth criterion in this study. Under different circumstances (i.e. a higher lake chubsucker: largemouth bass stocking ratio and/or absence of northern pike) the possibility that lake chubsuckers can maintain a viable adult population in combination with a dominant largemouth bass population still exists however.

Eggs or fry of fish were never observed in the diets of Site 054 lake chubsuckers. However, due to the limited time period in which these food items are present and the small number of lake chubsucker diets examined during this time period, the possibility of either food item going undetected was substantial. Nevertheless, literature indicates lake chubsuckers frequently lay eggs in largemouth bass nests occupied by a guarding male. Assuming largemouth bass would not tolerate lake chubsuckers any more than any other species representing a threat to their eggs, together with relevant food habits data from this study, it is therefore concluded that consumption of eggs or fry in sufficient numbers to significantly affect largemouth bass production is unlikely. Concerning the potential for competition, only food overlap was examined. Based on the low values calculated, it was concluded that there was no justification for concern with respect to competition for food. Thus Bennett and Childers' (1966) fifth criterion has been satisfactorily met with respect to those items examined.

Bennett and Childers' (1966) sixth criterion deals with a forage fish's capability of changing the physical or biological characteristics of the fish habitat. Chemical characteristics were also included in this analysis. Mean annual total alkalinity and Secchi disk transparency changed significantly over the study period, however it was determined that lake chubsuckers were not directly responsible since density changes in their population did not coincide. Likewise, aquatic vegetation was never found in the diets of the lake chubsuckers examined and the lake chubsucker population decrease paralleled decreasing aquatic macrophytes, resulting in the conclusion that these fish were not directly responsible for changes in the aquatic macrophyte community. Indirectly lake chubsuckers may have affected both Secchi disk transparency and aquatic macrophytes through alteration of the zooplankton community. Analysis of the plankton community was not included in this study resulting in insufficient data upon which to draw conclusions concerning Bennett and Childers' (1966) sixth criterion.

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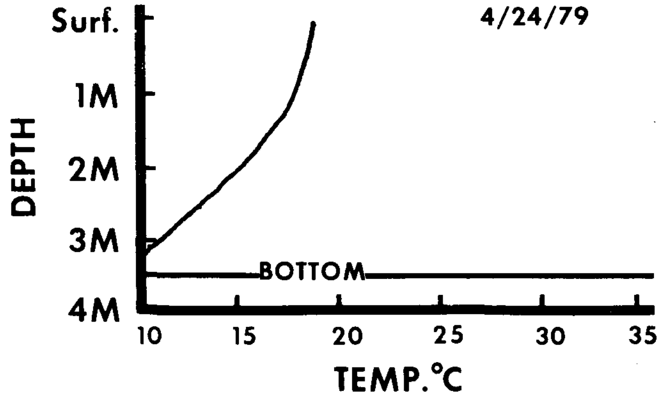
APPENDICES



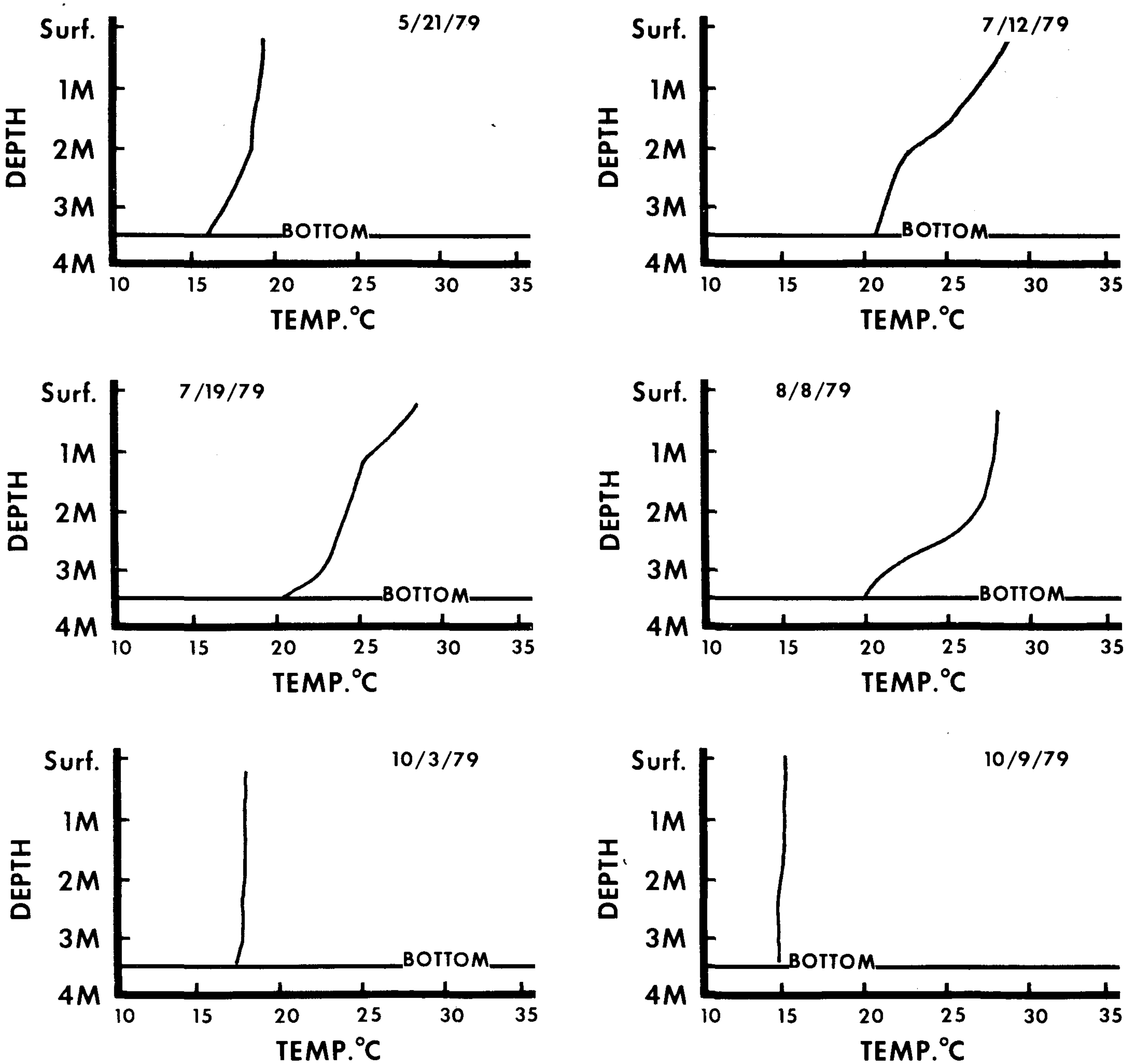
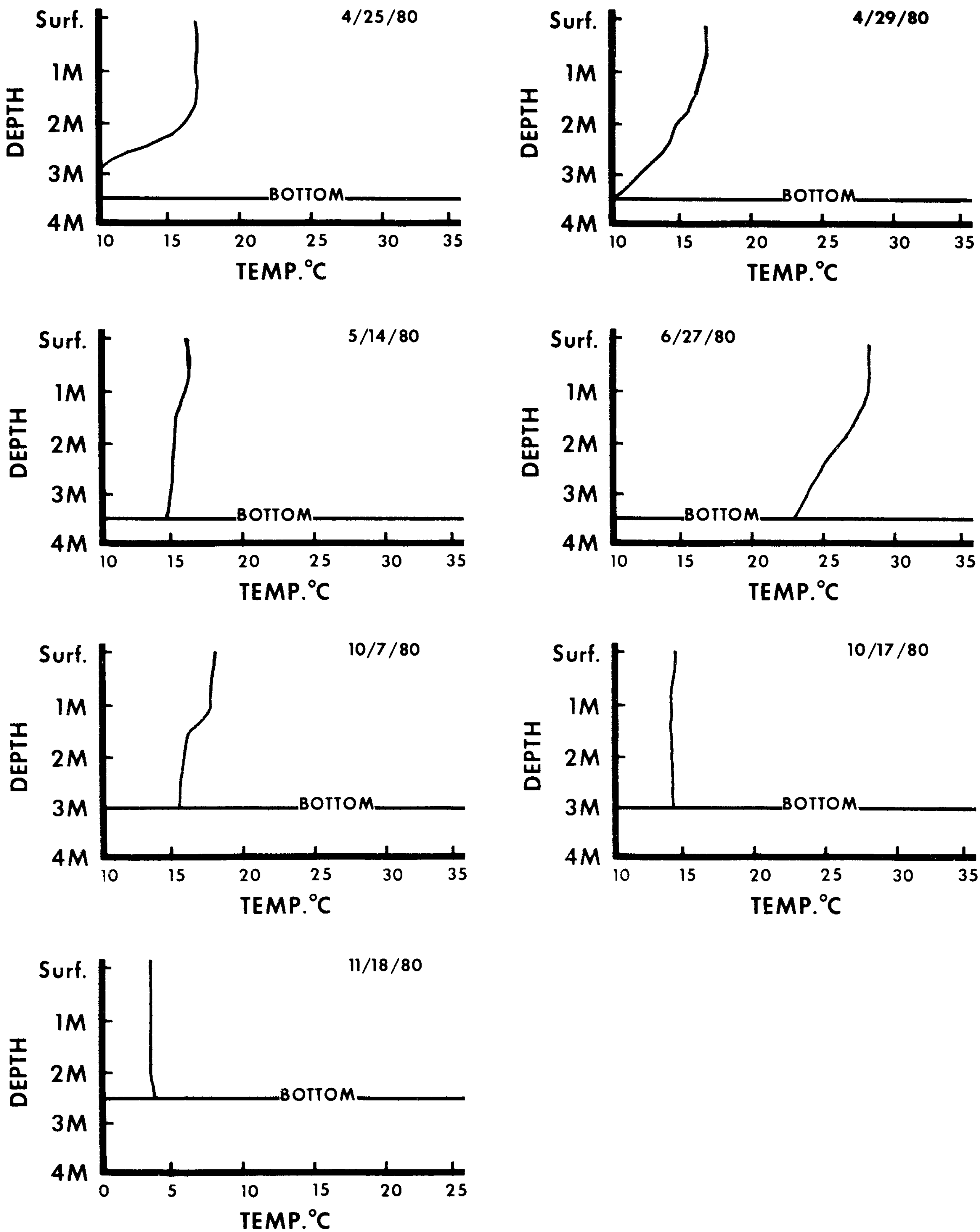


Figure 1. Temperature profiles for Site 054 during 1979, 1980 and 1981.



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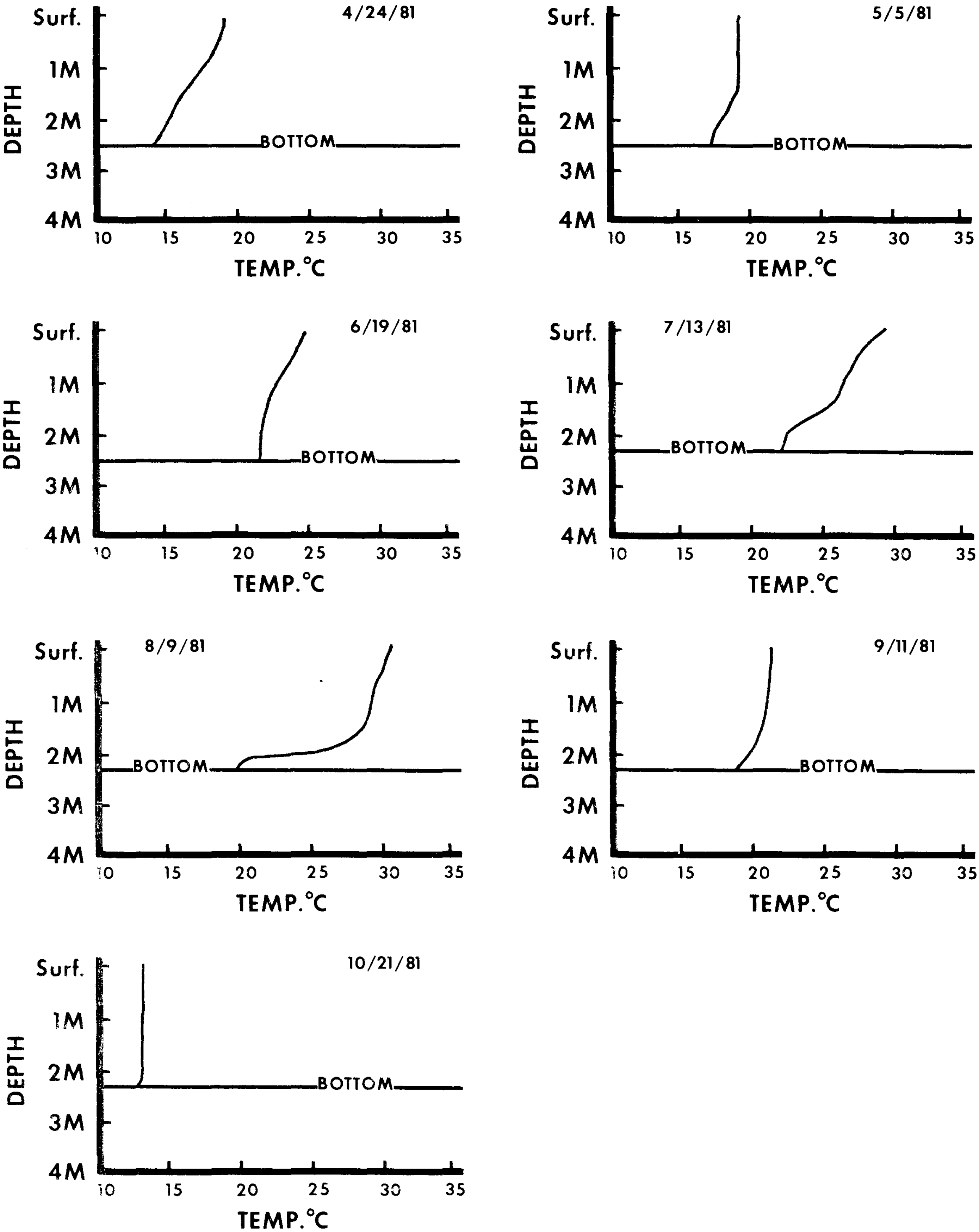

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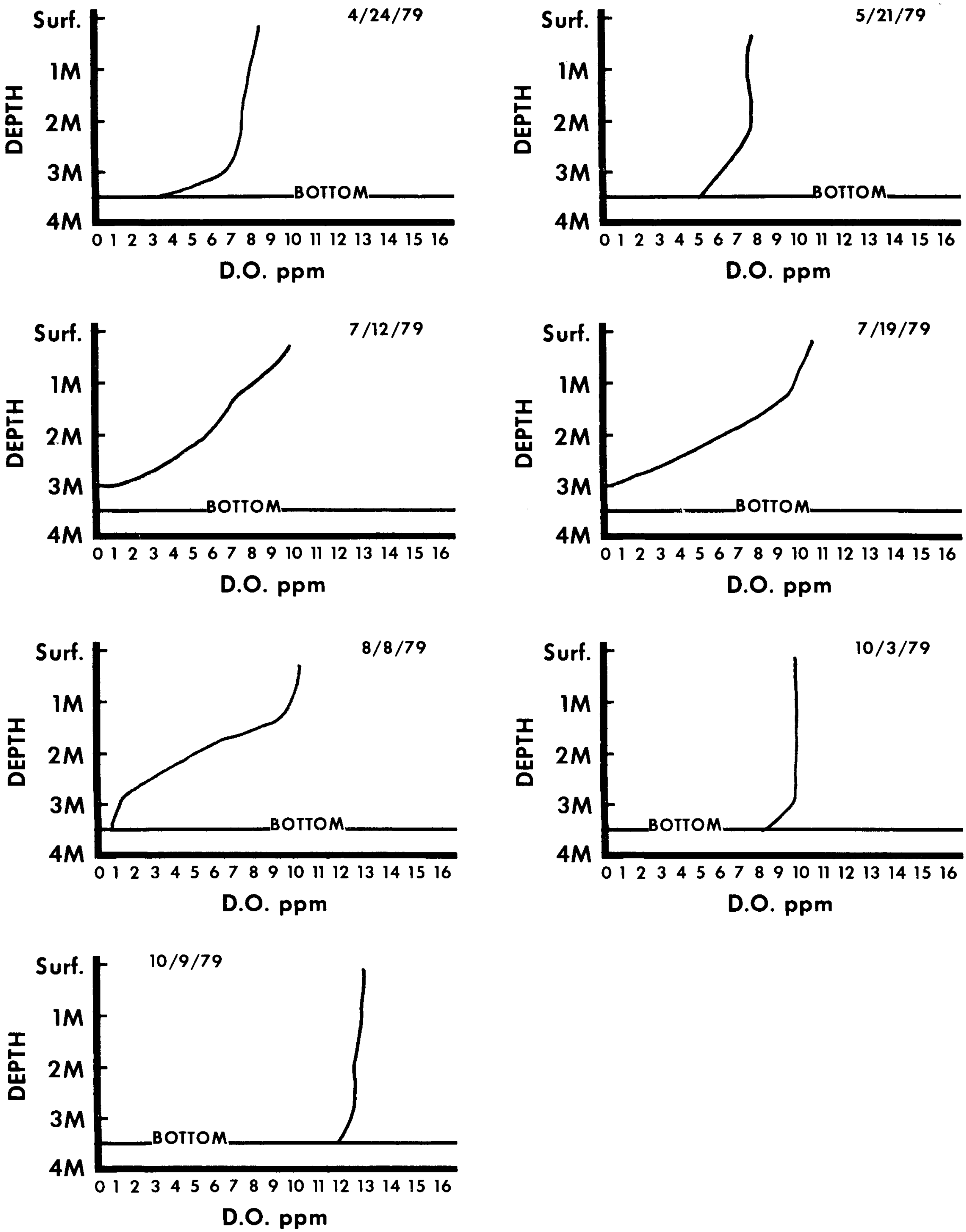
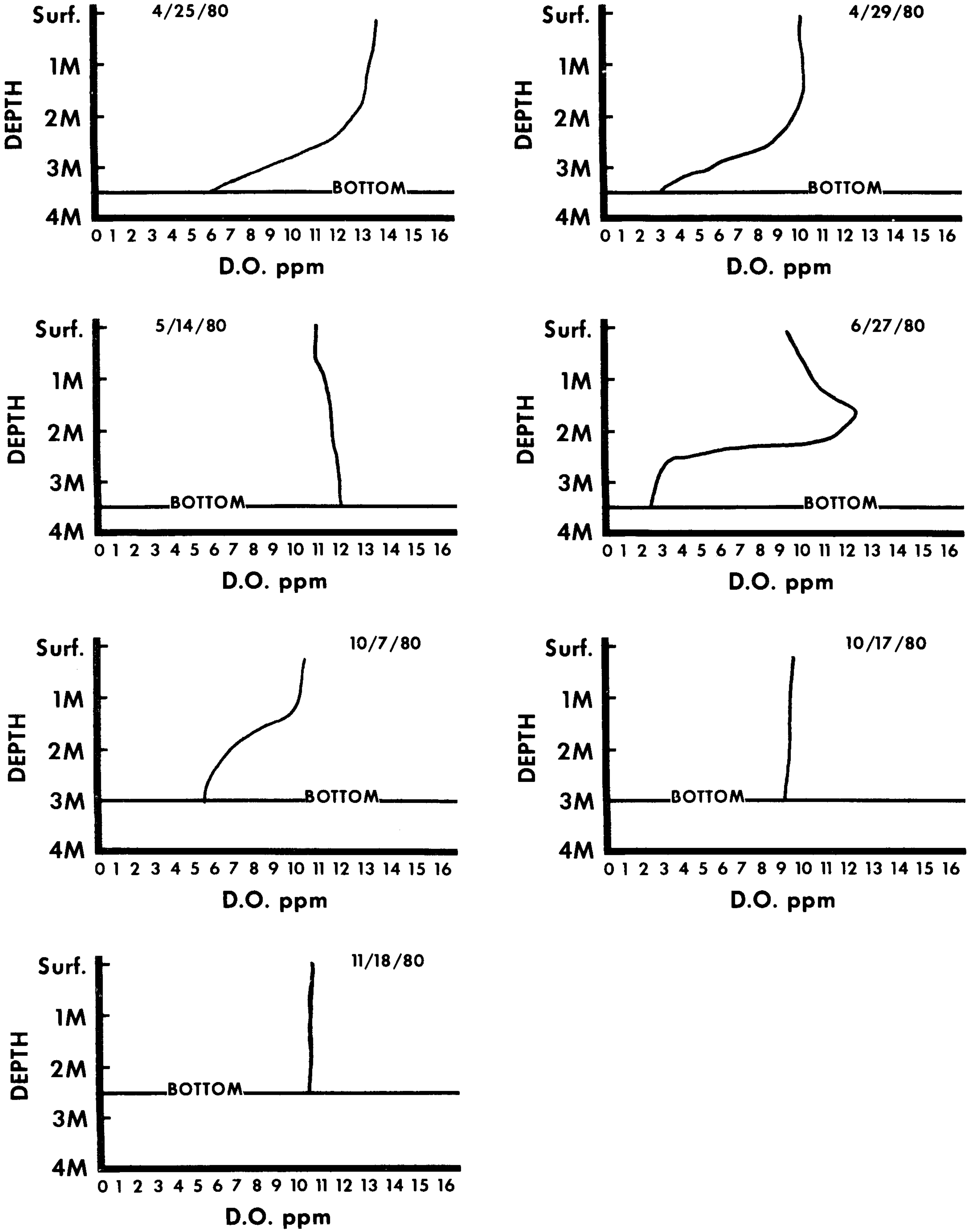


Figure 2. Dissolved oxygen profiles for Site 054 during 1979, 1980 and 1981.



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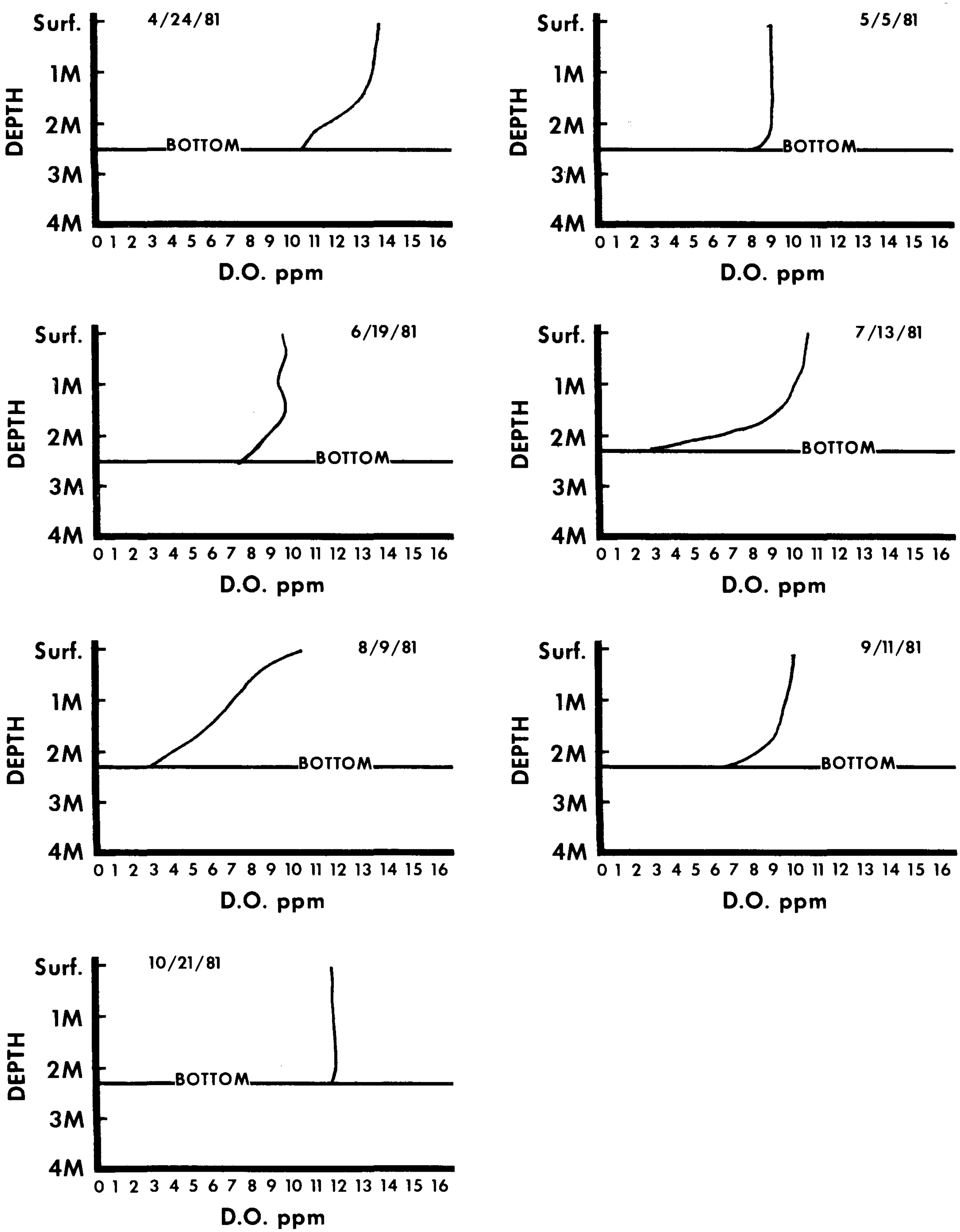

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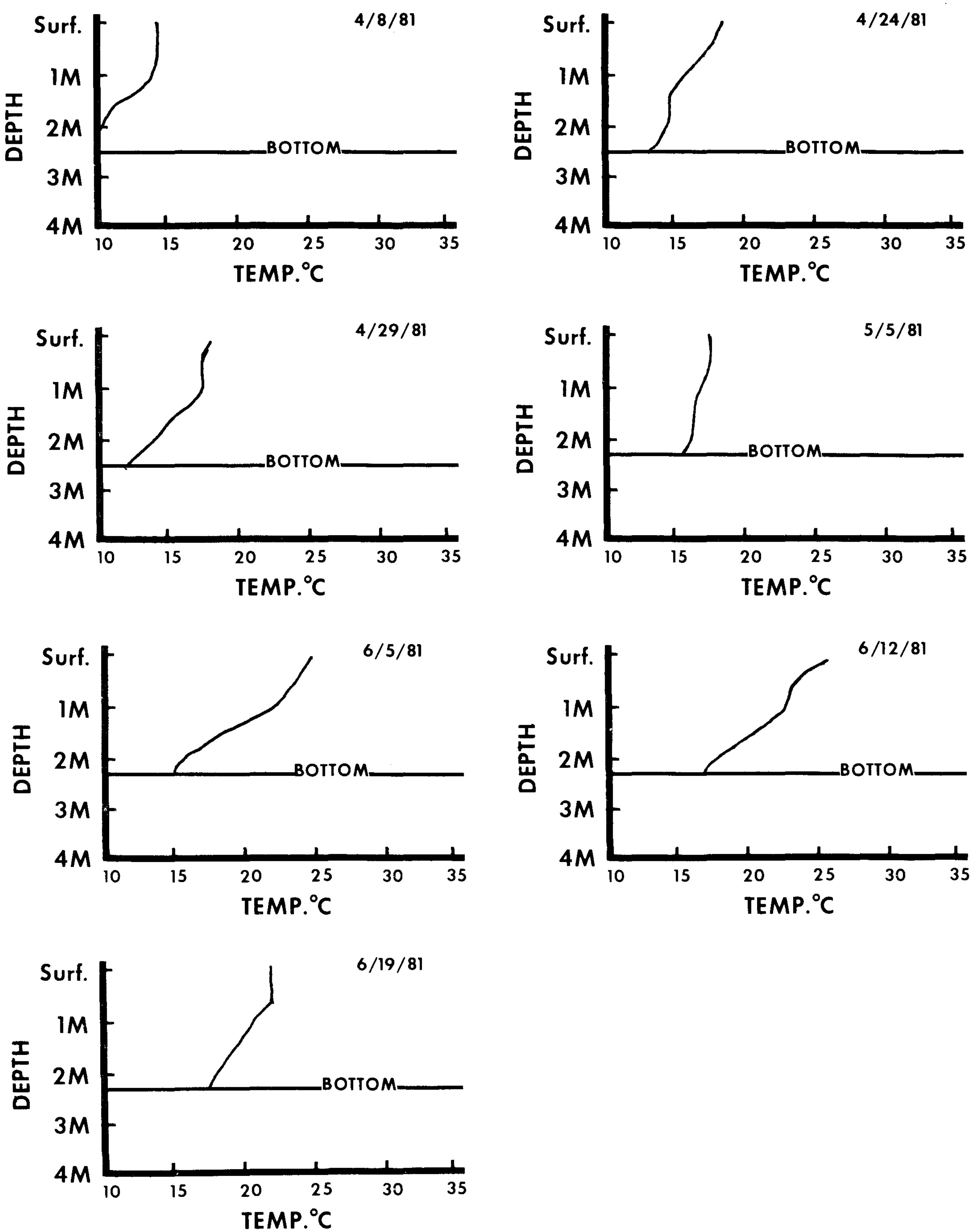

Figure 3. Temperature profiles for Site 059 during 1981.

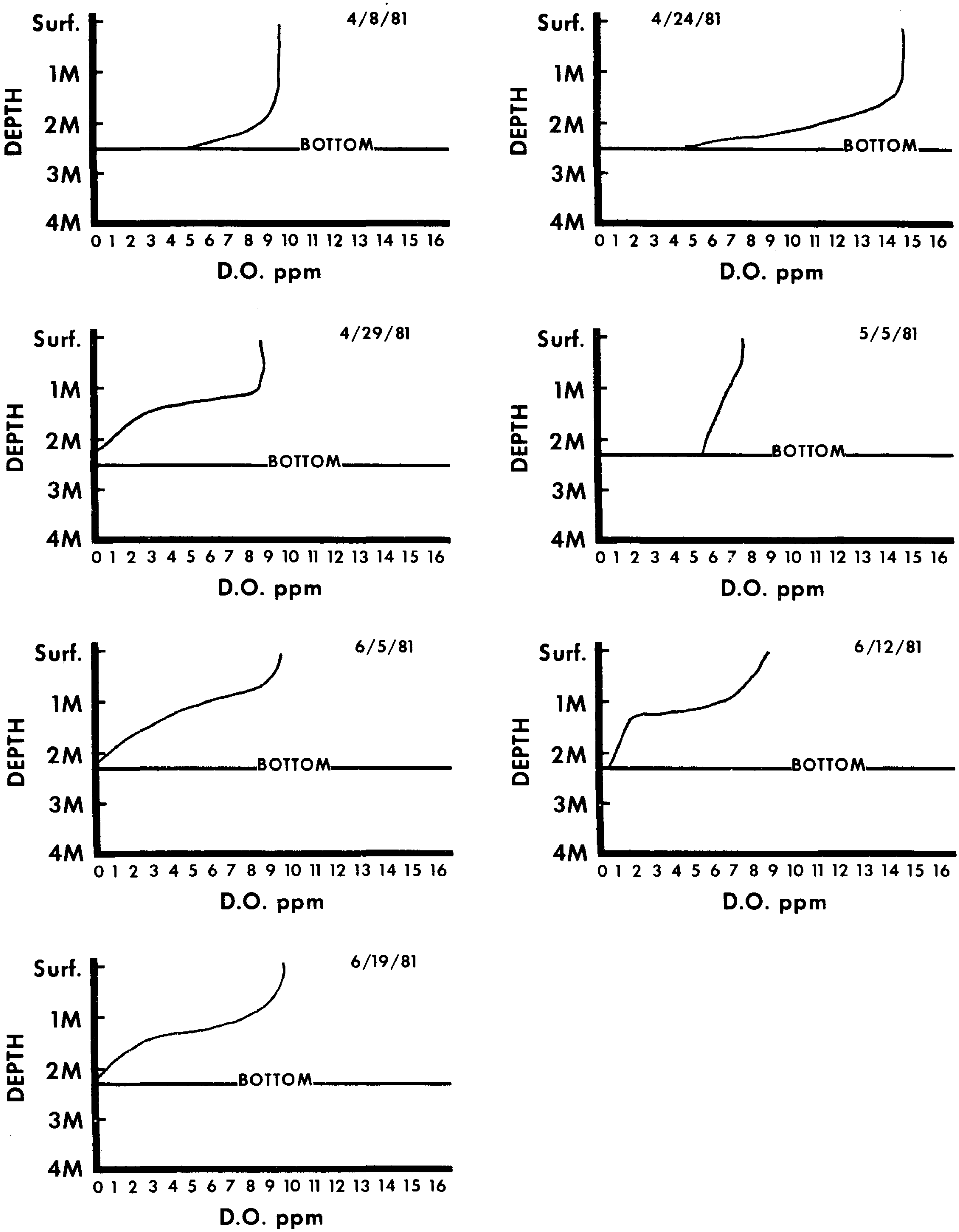

Figure 4. Dissolved oxygen profiles for Site 059 during 1981.