THE ZOOPLANKTON COMMUNITY OF CADDO LAKE TEXAS AND LOUISIANA, A LAKE WITH NUMEROUS OFFSHORE OIL WELLS

by

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THE ZOOPLANKTON COMMUNITY OF CADDO LAKE TEXAS AND LOUISIANA,

A LAKE WITH NUMEROUS OFFSHORE OIL WELLS

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INTRODUCTION

The zooplankton community is described as weakly swimming or floating heterotrophic organisms in an aquatic environment (Hutchinson 1967). The community plays an important role in the aquatic food chain between planktivorous fish, fish fry, small invertebrates and the phytoplankton community. Furthermore, the zooplankton community can be used as indicators of water quality.

Although there have been several studies of the effects of offshore oil production on the marine biota, studies of possible effects of those activities on freshwater organisms are rare.

Caddo Lake was chosen as a study site to examine the interactions between the zooplankton community and oil production in a freshwater environment. Offshore oil production began on Caddo Lake in the early part of this century and now there are approximately 200 active oil wells in the lake. Since this oil field has been active for such a long period of time, Caddo Lake offers a unique opportunity to investigate some possible long term effects from occasional crude oil and brine water spills on the freshwater ecosystem. Caddo Lake is one of the largest natural lakes in Texas and Louisiana. It has a shallow basin with a mean depth of 1.8 meters and a surface area of 132.09 sq Km (U.S. Environmental Protection Agency, 1977). However, much of this surface area consists of bald cypress swamps, and during the summer months most of the surface is covered with floating aquatic vascular plants. The lake is used as a water source for domestic and industrial use as well as recreational activity.

The objectives of this study were to:

1. Determine the density and composition of the zooplankton community, both temporally and spatially.

2. Identify some possible effects of offshore oil production on the zooplankton community.

AREA DESCRIPTION

Caddo Lake is located in Caddo Parish, Louisiana, and in Harrison and Marion Counties, Texas. It is approximately 30 Km northeast of Marshall, Texas and approximately 30 Km northwest of Shreveport, Louisiana. The lake has a drainage basin of 7101 sq Km [U.S. Environmental Protection Agency, 1977] with 6835 sq Km located in Texas. The drainage basin is mainly forested, but has some pasture and recreational land-use (Texas Water Quality Board, 1977). The major tributary of Caddo Lake is Cypress Bayou. Much of the water in Cypress Bayou flows from Lake O' the Pines Reservoir, 33 Km west of Caddo Lake. Smaller tributaries include: James Bayou, Kitchen's Creek, Harrison Bayou, Watson Bayou and Tiger Branch.

Caddo is one of the largest natural lakes in Texas and Louisiana. It was formed by a series of logjams on the Red River known as the "Great Raft", which extended 250 Km from Arkansas to Alexandria, Louisiana. Indian legends however, suggest that Caddo was formed during the New Madrid earthquakes of 1811 and 1812. According to Walker (1983), the logjam impounding Caddo was removed in 1873 forming a smaller lake than that which is present today. In 1914, Caddo Dam was constructed by the United States Government to bring the pool elevation to the present level of 51.36 meters above mean sea level. In 1971, the existing earthfill dam was constructed by the U.S. Army Corps of Engineers, to replace the older dam. The dam is owned by the Board of Commissioners, Caddo Levee District (Texas Water Development Board, 1974).

The surface area of Caddo Lake is 132.09 sq Km with a mean depth of 1.8 meters, and a volume of 231.896 X 10^6 cubic meters (U.S. Environmental Protection Agency, 1977). The mean hydraulic retention time at Caddo Lake was calculated by the U.S. Environmental Protection Agency (1977) to be 42 days. Due to the shallowness of the lake, a large percentage of the backwater area displays a prolific seasonal growth of aquatic macrophytes in association with bald cypress swamps.

The lake overlies two major geologic formations: Recent alluvium and the Wilcox group. The Wilcox group is a silt and sand formation with beds of clay, lignite, silt and quartz sand. Ironstone deposits are also common in the formation. The highly productive Caddo-Pine Island oil and gas field is located in James Bayou in the eastern area of the lake. Oil is pumped from 274 meters to 2540 meters below the surface (Shreveport Geological Society, 1953). Intense oil production began during the 1920's, and some of the first off-shore platform oil wells were constructed on Caddo Lake. Over 100 producing off-shore oil wells could be seen from the sampling stations in this region. The total number of wells on the lake is estimated at 200.

Caddo Lake is a source of water for the surrounding region. Water flows from Caddo, down Twelvemile Bayou to the city of Shreveport, Louisiana, where it is used as a domestic water source. The lake also provides domestic and industrial water for Mashall, Texas, as well as, for the Southwest Electric Power Company generating plant for their once-through type cooling system. The hot water discharge is near the dam. Caddo receives wastewater from Longhorn Ordinance Plant at Karnack, Texas and also receives municipal wastewater from Jefferson, Texas by way of Cypress Creek Bayou.

Nine sampling stations were chosen to characterize the zooplankton community of Caddo Lake (Figure 1.). Stations 1,2, and 3 were located in the bald cypress swamp region. Stations 4,5,6 and 7 were located in the relatively unsheltered open water region of the lake, while stations 8 and 9 were located in the oil producing region. The exact locations of the sampling stations were as follows:

Station 1 was located at Devil's Elbow in the channel of Cypress Bayou; it was approximately 1.6 Km north of Uncertain, Texas. The depth at this station was about 6 meters.

Station 2 was located in the downstream portion of a region known locally as "Government Ditch" about 500 meters north of Uncertain, Texas. The depth at this station was 2 meters.

Station 3 was located approximately 200 meters east of Uncertain, Texas, in a back-water area known as Turtle Shell Lake. The depth was 1 meter.

Station 4 was located near Twin Island on Boat Lane 1-P approximately 800 meters north of Long Point. The site was about 50 meters east of the furthest growth

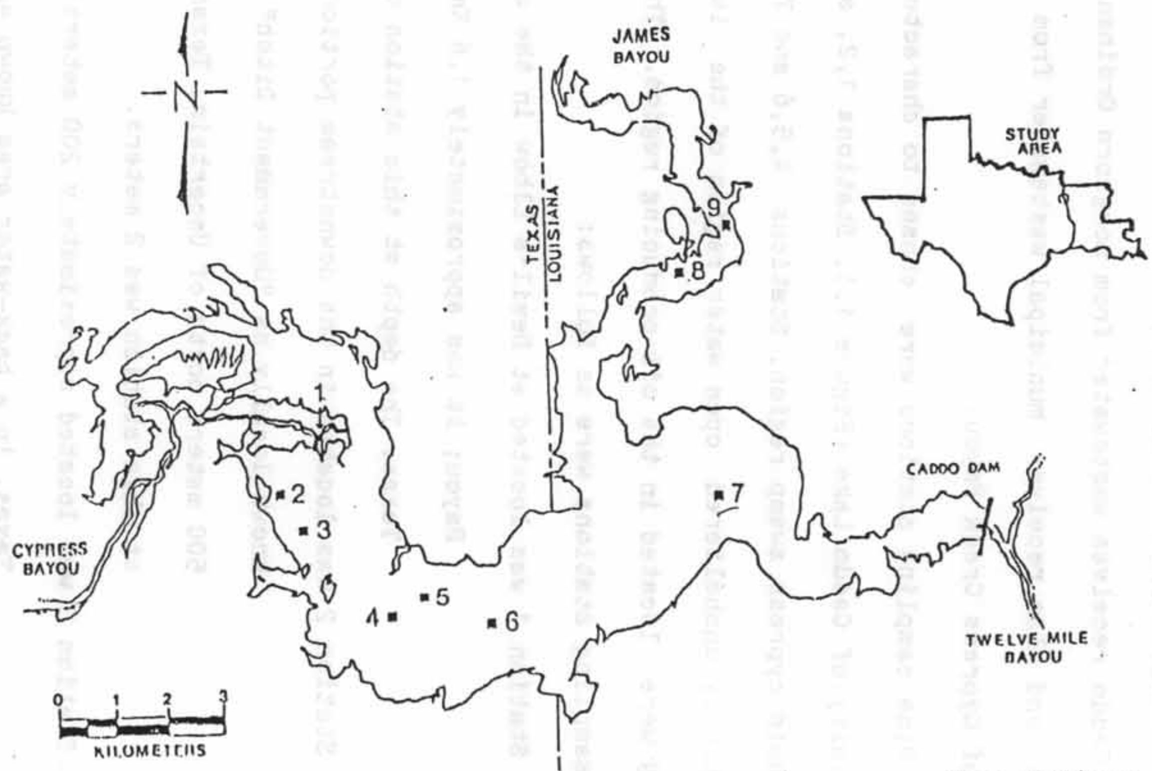

Figure 1. Map of Caddo Lake showing the locations of the sampling stations.

of lily pads (Nelumbo lutea and Nymphea odorata). The depth was approximately 1 meter.

Station 5 was located approximately 1 Km northeast of Long Point in a small grove of bald cypress near the intersection of Boat Lanes 5 and 1-D. The depth was approximately 1 meter.

Station 6 was about 1 Km south of Miller's Point near the crossing of Boat Lanes 5 and 1-M. The collecting site was near the Texas-Louisiana state line, and the depth was about 2 meters.

Station 7 was located about 1.1 Km south of Oil City, Louisiana in the open water area known as Big Lake. It was within 50 meters of the EMCO oil well #289. The depth was about 2 meters.

Station 8 was located approximately 2 Km northwest of Oil City, Louisiana in the oil producing portion of James Bayou near Boat Lane marker E-68. The station was situated close to the Allen Brothers oil well #23. This area is a highly productive region for offshore oil wells. The depth at this station was 2 meters.

Station 9 was situated about 200 meters west of the mouth of Tiger Branch in the northern part of James Bayou near Boat Lane marker E-76. The station was located between Allen Brothers oil wells Number 17 and 23. This was another highly productive region for offshore oil wells. The depth was approximately 2 meters.

LITERATURE REVIEW

Few studies were found which investigated the effects of offshore oil production on the freshwater environment. A publication by the Battele Memorial Institute, Pacific Northwest Laboratories (1974) reviewed some aspects of crude oil pollution and zooplankton populations on Lake Maricaibo, Venezuela. Only one successful bioassay was conducted on the lake using cyclopoid copepods. The copepods were selected at random and placed in glass petri dishes in 25 ml of filtered lake water. A water phase with 1600 ml of oil to 15 liters of water was used, along with filtered lake water to give the desired dilutions. The results showed an increase in mortality of these copepods at 1 gram per liter (1 part per thousand) of crude oil.

Caddo Lake is an unusual body of freshwater because of the presence of producing oil wells in the lake. Although no intensive zooplankton studies have been done on the lake, Hartung (1983) examined the water quality of Caddo Lake over a one year period. Using Carlson's (1977) trophic index, in conjuction with Secchi disc transparency and total phosphorous values, he determined that Caddo was eutrophic. He also concluded that Caddo did not experience a spring phytoplankton bloom; it did however, according to phytoplankton chlorophyll a data, exhibit a fall bloom in phytoplankton. In 1977, the U.S. Environmental Protection Agency and the Texas Water Quality

Board both studied the water quality of Caddo Lake; their studies however were based on single samples.

The City of Shreveport, Louisiana has been monitoring a few water chemistry parameters at one location on Caddo Lake since 1956 (Water and Sewerage Department of Shreveport, Louisiana, 1982). The U.S. Geological Survey (1975, 1982) has reported some water chemistry data from Caddo Lake since 1960. Duncan (1964), Shampine (1971) and Leifest (1968) conducted studies on Caddo which contain some fish population data and water chemistry results. Texas Parks and Wildlife has also accumulated unpublished fish population data for Caddo Lake.

Hartung (1983) reported significantly higher chloride concentrations at some of the collecting sites during his study of the physicochemical limnology of Caddo Lake, Texas and Louisiana. These elevated chloride levels may inhibit rotifer production. Williams (1966) reported that high chloride concentrations, at some of his stations in the main waterways of the United States, destroyed the rotifer population. Rogers (1976) hypothesized that high chlorides on Striker Creek Reservoir inhibited rotifer populations.

Shireman and Martin (1978) examined the zooplankton community of a shallow south-central Florida lake that contained a profuse growth of aquatic vascular plants. The depth and vegetative characteristics of that lake seemed to be similar to conditions found at Caddo. Their results showed cladocerans to be the most numerous and diverse group in the zooplankton community. The high diversity was attributed to the large amounts of vegetation. Generally, the density of the zooplankters was the lowest during the winter. They also found that rotifers showed the greatest seasonal population differences, with January being the least productive month for this taxon. Most of the cladocerans they collected were littoral species. The dominant zooplankters in their lake were: Keratella, Conochilus unicornis and Diaphanosoma brachyurum. Goddard and McDiffet (1983) examined rotifer distribution and community structure in four habitats of a freshwater marsh located in central Pennsylvania. They found a total of 32 species of rotifera. Rotaria rotatoria was the most abundant rotifer. The large number of species was attributed to the littoral characteristics of the marsh. They also found no correlation between rotifer numbers and phytoplankton chlorophyll a concentrations. McCullough et al. (1979) studied the aquatic ecology of Bayou Pierre, Louisiana and its tributaries. They found that crustaceans dominated Bayou Pierre in all but the first month of sampling. Nearby, at Shell Bayou, Flatt River and Bull Bayou, the crustaceans showed intermittent dominance. The dominant rotifers in Bayou Pierre were: Brachionus, Cephalodella and Platyias. The dominant copepods for this Bayou were: Senecella and Eucyclops. In the other tributaries the dominant rotifers were: Tricocerca and Cephalodella. The dominant copepods were: Cyclops and Ectocyclops.

Gannon and Stemberger (1978) developed trophic indicators using the zooplankton community. Some oligotrophic indicator species were:

Daphnia longiremis, Asplanchna herricki, Limnocalanus macrurus and Senecella calanoides. The eutrophic indicator species included: Bosmina longirostris, Keratella taurocephala, and Synchaeta asymetrica. Hutchinson (1967) discussed the distribution of plankton populations, and concluded that rotifers typically dominate riverine environments while cladocerans and copepods typically dominate the lacustrine environment.

Brooks and Dodson (1965) investigated the effects of grazing by a marine planktivore on the zooplantkon community. They determined that planktivores and piscivores select their food on the basis of size, abundance, edibility and the ease with which the prey could be caught. They also hypothesized that the larger, more visible organisms may be selected for over the smaller and/or less visible organisms. Thus, population composition of zooplankters may shift depending upon predation intensity. O'Brien (1979) studied the predator-prey interaction of planktivorous fish on the zooplankton community. He suggested the following sequence for predator-prey interaction: locating the prey, pursuit, attack and capture. He also stated that locating the prey is the most important aspect of the sequence, thus, the larger, easier to locate zooplankters may receive more predation pressure than the smaller ones. Hardy (1935) investigated algal defenses against grazing by zooplankters. He hypothesized that phytoplankton exude a repellent that excludes grazers from regions of high phytoplankton productivity. Hasler and Jones (1949) found that zooplankters seem to avoid highly vegetative areas and that some die when confined to such areas. Porter (1977) proposed that toxicity of vegetation may not be the reason for avoidance by zooplankters, but, avoidance may be due to energy expenditure from zooplankters colliding with aquatic vegetation.

There are several zooplankton studies that have been conducted on reservoirs and ponds in eastern Texas region. When Allard (1977) examined the zooplankton population dynamics of Sam Rayburn Reservoir, he found maximum population densities of zooplankters during February, with copepods being the only taxon showing seasonal differences. Rogers (1976) examined the relationship between the zooplankton community and a thermal effluents at Striker Creek Reservoir. He suggested that chlorides had an inhibitory effect on the rotifer community. Swearingen (1978) measured the zooplankton community at Livingston Reservoir and found that rotifers comprised 64% of the zooplankton community. Kines (1980) studied the zooplankton community and primary productivity of Nacogdoches Reservoir. She found an annual mean standing crop of 41.6 org/l, but adult copepods were not a major constituent of the zooplankton community. She found no correlation between the zooplankton numbers and either primary productivity or phytoplankton density.

METHODS AND MATERIALS

Zooplankton samples were collected from October 1981 through September 1982, using a Teel submersable pump, Model H-Ip809, powered by a McCulloch portable generator, Model H-1500. The pump was calibrated to pump 33 liters per minute. Water was pumped through a No. 20 plankton net (76 micron) drawing from the entire water column in one meter intervals. At each interval the pumping lasted 60 seconds and after pumping water from the whole column, the zooplankters were emptied into containers and chilled to prevent decomposition and predation. The plankton net was washed with distilled water between stations. In the laboratory, the samples were warmed to room temperature, narcotized, stained and preserved. They were then concentrated to a volume of 25 ml. Narcotization then staining were done with 95% ETOH and a tincture of 1% (w/v) Rose Bengal and 95% ETOH, respectively. Three tenths of a ml of the Rose bengal solution was added to each of the nine samples. This solution was added twice to the samples at 15 minute intervals. Next, a 95% solution of ETOH was added in the following increments: 0.3 ml, 0.5 ml, 0.8 ml, 1.5 ml and 5.0 ml; an interval of 15 minutes was used between each increment. Two hours later the volume was raised to 40 ml using 95% ETOH. After forty-eight hours, 10 ml of formalin was added to complete the preservation.

Total numbers of organisms per liter, were determined by placing a one ml aliquot of the sample, using a Hensen-Stemple pipette, into a Sedgwick-Rafter counting chamber. The counts made on the samples were converted to organisms per liter using the following equation:

$$N = a(b)/c \quad \text{where:}$$

N = The number of organisms per liter of lake water.

a = The average number of individuals per ml of the sample.

b = The total number of ml of the preserved sample.

c = The total number of liters filtered through a No. 20 nylon mesh net.

Identifications were made using Pennak (1978), Ward and Whipple (1959) and Brooks (1957). The zooplankters were identified to the lowest taxon possible.

Statistical Methods

A one-way analysis of variance (ANOVA) (Dunn and Clark, 1974) was used to determine if significant differences existed between the stations and the zooplankton taxa and total numbers or between the four seasons and the zooplankton taxa and total numbers.

Their model was:

$$Y_{ij} = \mu + T_i + E_{ij}$$

where:

Y_{ij} = the observed value.

μ = the overall mean for all the populations.

T_i = the deviation of the ith population mean from the overall mean.

E_{ij} = the random deviation from the mean of the ith population.

and:

i = the number of seasons or stations.

j = the number of observations per season or station.

A Duncans New Multiple Range Test was run on the One-Way ANOVA to determine if significant differences existed among the groups. A completely randomized two-way ANOVA from Dunn and Clark (1974) was used to detect any significant differences among zooplankton numbers, taxa, seasons, and stations and any interaction between these variables. The model was:

$$Y_{ijk} = \mu + A_i + B_j + (AB)_{ij} + E_{ijk}$$

where:

Y_{ijk} = the kth observation of the ith station and jth season of the observed parameter.

μ = the overall mean for the population.

A_i = the effect of the ith station.

B_j = the effect of the jth season.

$(AB)_{ij}$ = the interaction between the ith station and the jth season.

E_{ijk} = the random deviation of Y from the population mean for the population.

and:

i = the number of stations.

j = the number of seasons.

k = the number of observations per season.

Correlation Coefficients between physio-chemical parameters and zooplankton numbers and groups were calculated using the Pearson's Correlation Matrix (Nie, et al. 1975).

A Community Ordination Matrix (Beals, 1960, Bray and Curtis, 1957) was computed for the year. This matrix determines similarities between the stations for the year based on species and numbers.

Species Diversity (d) was calculated, using the Shannon Diversity Index (Shannon and Weaver, 1949), for the year, season, region, and station. The formula used for this computation was:

$$d = -(n/N) \log (n/N)$$

where:

n = the number of individuals of the ith species.

N = the number of individuals of all species.

d = the diversity value.

Statistical analyses were made using a CP-6 computer.

RESULTS AND DISCUSSION:

Spatial and Temporal density:

A total of 42 taxa were collected from the collecting sites over a one year period (Table 1). Hartung (1983) found Caddo Lake to be a shallow, warm-water monomictic, eutrophic environment. The annual mean zooplankton density of 59.6 org/l suggests a eutrophic condition. Kines (1981) found 41.6 org/l as a annual mean zooplankton density value for mesotrophic Nacogdoches Reservoir, Texas; Swearingen (1978) found an average density in eutrophic Livingston Reservoir, Texas of 59.3 org/l; Allard (1974) found the annual density to be 56.0 org/l at Sam Rayburn Reservoir, Texas and Rogers (1976) reported means of 22.3 and 29.6 org/l, respectively, for Striker and Murvaul Reservoirs, Texas.

The high annual density of zooplankton at Caddo would seem to indicate a large population throughout the year, however, this is not the case. The populations varied greatly in each region and during each season. Figure 2 illustrates the monthly mean zooplankton density for the lake during the sampling period. Three productive months are shown in the graph: September, November and December. Regional and seasonal trends in the zooplankton community and the major taxa are listed in Figures 3 and 4. A similarity can be seen between these two graphs. The fall was the most productive season for the zooplankton community. The winter and summer exhibited the lowest seasonal values with the spring showing a slight pulse. The results from a 2-Way ANOVA

Table 1. List of taxa collected during the sampling period at Caddo Lake.

TAXA	STATIONS 1	2	3	4	5	6	7	8	9
Phylum Arthropoda									
Class Crustacea									
Subclass Branchiopoda									
Order Cladocera									
Acropterus			X						
Bosmina longirostris	X	X	X	X	X	X	X	X	X
Bosminopsis detersei	X			X	X	X	X	X	X
Camptocercus			X		X			X	
Ceriodaphnia		X			X		X		X
Chydorus sphaericus	X	X	X	X	X	X	X	X	X
Daphnia longispina	X	X		X					
Daphnia pulex	X	X	X	X					
Eurycercus	X	X	X		X		X		X
Illyocryptus	X	X	X	X	X	X		X	
Leydigia									X
Macrothrix	X			X	X				
Pleuroxus	X	X	X	X	X	X	X	X	X
Sida crystilina	X	X		X	X	X			
Simocephalus serrulata	X	X	X	X	X	X	X	X	X

Table 1. (Cont.)

Phylum Rotatoria

Asplanchna	X	X	X	X	X	X	X	X	X
Brachionus angularis	X	X	X	X	X	X	X		X
Brachionus capitulosa		X			X	X		X	
Conachiloides	X	X	X	X	X	X	X	X	X
Filinia			X						
Kellicottia	X	X		X	X	X	X	X	
Keratella cochlearis	X	X	X	X	X	X	X	X	X
Lecane	X	X	X	X	X	X	X	X	X
Notommata	X	X	X	X	X	X		X	X
Philodina		X	X	X	X				
Platyias puatulus	X	X	X	X	X	X	X	X	X
Platyias quadracornis	X	X	X	X	X		X		X
Pleosoma			X	X	X		X		X
Polyarthra	X	X	X	X	X	X	X	X	X
Pompholyx	X	X				X	X	X	X
Rotaria		X	X	X	X	X	X	X	X
Scaridium		X	X		X		X		
Syncheata	X	X		X	X	X	X	X	X
Testudinella	X	X			X				
Tricocerca	X	X	X	X	X	X	X	X	X
Trochosphaera solstitialis			X		X				

Table 1. (Cont.)

Phylum Arthropoda

Class Crustacea

Subclass Copepoda

Order Eucopoda

Cyclops bicuspidatus	X	X	X	X	X	X		X	X
Diaptomus siciloides	X	X	X	X	X	X	X	X	X
Ergasilis	X	X	X		X			X	X
Eucyclops				X					
Limnocalanus		X	X	X	X		X	X	
Mesocyclops edax			X	X	X		X		
(immature copepods)	X	X	X	X	X	X	X	X	X

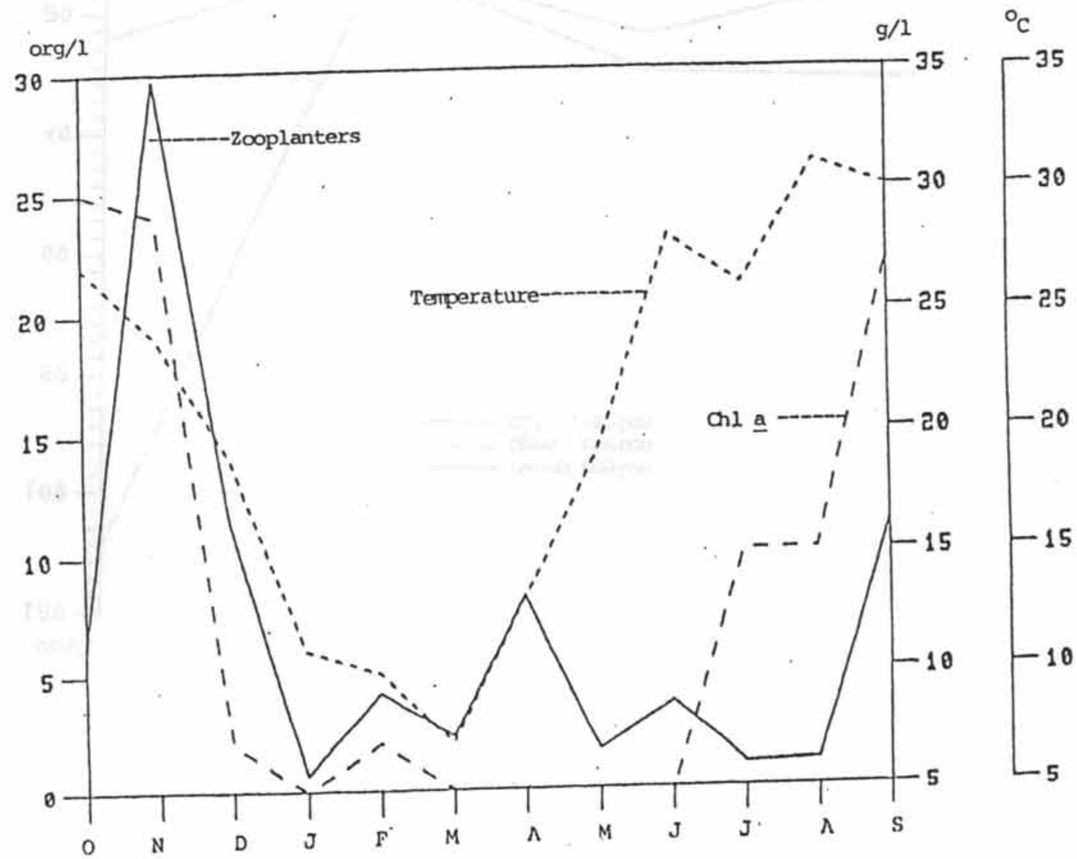

Figure 2. Monthly values for the zooplankton community, chlorophyll a and temperature.

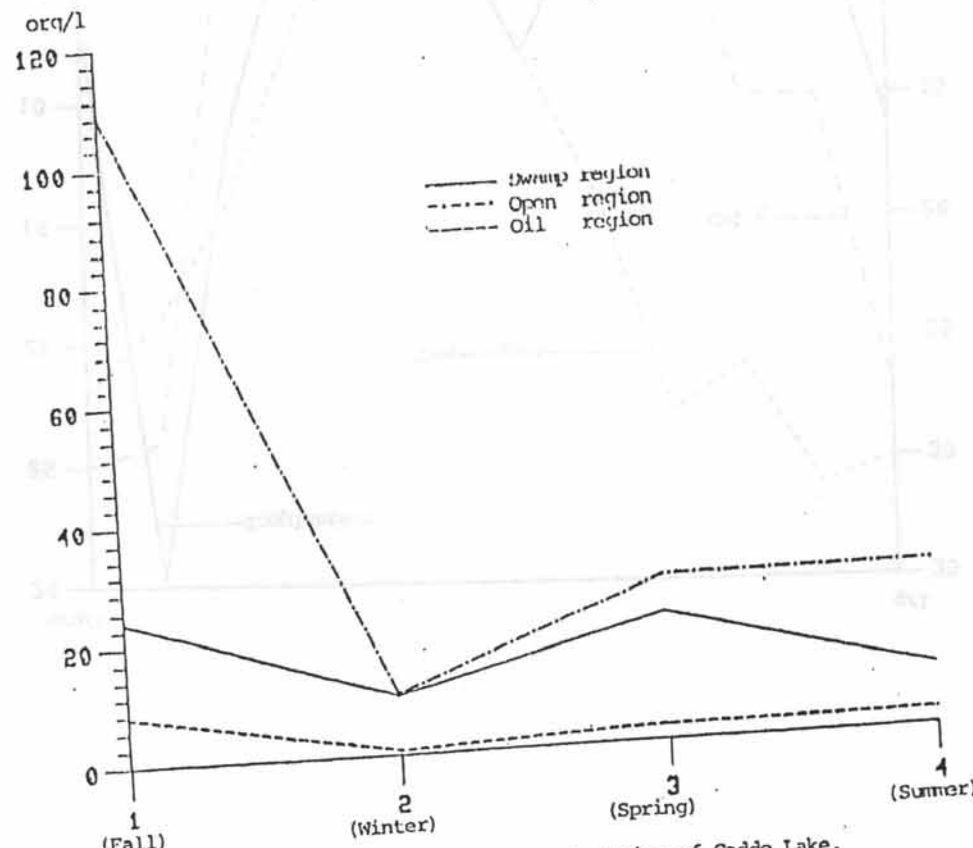

Figure 3. Zooplankton density for each region of Caddo Lake.

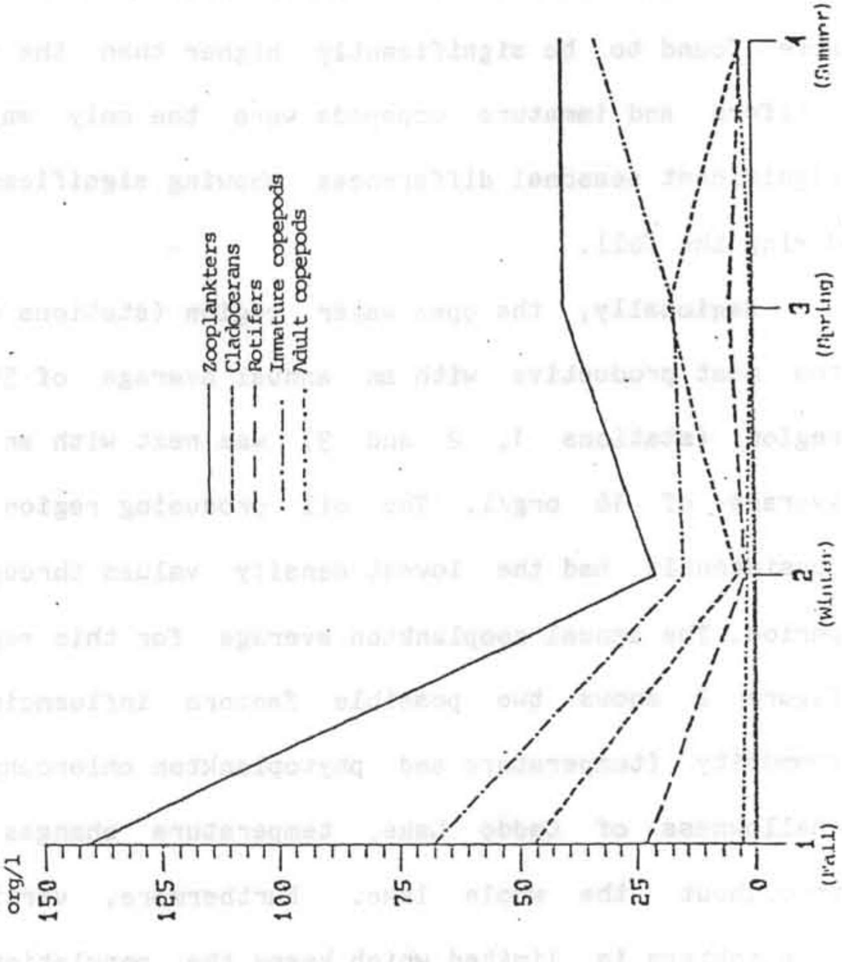

Figure 4. Season means for major zooplankton taxa at Caddo Lake.

between the zooplankton numbers, the stations and seasons are given in Table 2. Significant differences between stations and seasons are indicated in this table. Zooplankton numbers during the fall season were found to be significantly higher than the other seasons. The rotifers and immature copepods were the only major taxa to exhibit significant seasonal differences showing significantly higher numbers during the fall.

Regionally, the open water region (stations 4, 5, 6 and 7) was the most productive with an annual average of 39 org/l. The swamp region (stations 1, 2 and 3) was next with an annual zooplankton average of 16 org/l. The oil producing region (stations 8 and 9) consistently had the lowest density values throughout the sampling period. The annual zooplankton average for this region was 4.5 org/l. Figure 2 shows two possible factors influencing the zooplankton community (temperature and phytoplankton chlorophyll a). Due to the shallowness of Caddo Lake, temperature changes can occur rapidly throughout the whole lake. Furthermore, vertical migration by zooplankters is limited which keeps the populations relatively close to the surface and exposed to greater predation. There is some evidence that water temperature may play a very important role in regulating zooplankton density. A decrease in water temperature and an increase in phytoplankton density during the fall may have approached optimum conditions for the zooplankton community and may explain the high productivity during this season. Shireman and Martin

Source	D.F.	SS	MS	F	P
Main effects	11	1518.781	138.071	2.93	.003
Stations	8	763.423	95.428	1.02	.057
Season	3	810.779	270.26	5.74	.002
Interaction	24	1339.36	55.807	1.85	.288

SEASONS:

Winter	Spring	Summer	FALL
2.3783	4.4467	4.6759	15.661

STATIONS:

1.210	1.395	2.584	3.365	3.641	5.843	8.763	(MEANS)
9	1	6	8	2	7	4	(STATIONS)

1.395	2.584	3.365	3.641	5.843	8.763	10.421	(MEANS)
1	6	8	2	7	4	5	(STATIONS)

2.584	3.365	3.641	5.843	8.763	10.421	11.206	(MEANS)
6	8	2	7	4	5	3	(STATIONS)

Table 2. A 2-Way Analysis of Variance and Duncan's Multiple Range Test of zooplankton numbers with stations and seasons for Caddo Lake.

(1978) found temperature to be a major factor controlling cladoceran numbers in a Florida lake (Lake Wales) very similar to Caddo Lake. Lake Wales, a south-central Florida lake, has a mean depth of 2 meters and is covered with dense mats of vegetation. The water temperature ranged from 15 C to 32 C. The lake did not thermally stratify, but it did show oxygen depletion in the deeper waters beneath dense mats of Hydrilla. According to phytoplankton chlorophyll a data, Lake Wales was mesotrophic; however, they pointed out that phytoplankton chlorophyll a was not a good indicator of trophic conditions, because of the competition between Hydrilla and the phytoplankton community. They also found that copepod abundance was related to seasons, which may reflect a temperature response. Hutchinson (1967) states that generally, an increase in water temperature through the tolerance range enhances development of cladocerans, copepods and rotifers. Goddard and McDiffett (1983) studied four habitats in a freshwater marsh and found a strong correlation between changes in temperature and rotifer production.

Zooplankters are capable of assimilating energy from a variety of food sources including: phytoplankton, bacteria, detritus, yeast and other zooplankters (Hutchinson 1967, Pennak 1978, and Ruttner-Kolisko 1974). Therefore, one might not expect variations in zooplankton populations to always parallel variations in phytoplankton density.

Spatially, the open water region (stations 4, 5, 6 and 7) was the most productive for the zooplankton community with an annual average of 39.0 org/l. The high productivity in zooplankton for this region is mainly attributed to station #4 (Figure 5). Station 4 is an ecotone between the swamp and open water zones and the increase both in numbers and taxa here is probably a manifestation of the "edge effect". The decrease in density at station #6 is attributed to a decrease in niche diversity and possibly to heavier grazing from planktivorous fish in this more open water environment. Prophet (1982) found that threadfin shad (Dorosoma petenense) drastically reduced zooplankton density values in a Kansas lake. This reduction resulted in a zooplankton population of naupliar and early copepodite stages, a few small cladocerans and rotifers, a community not unlike that found at Caddo Lake. Pennak (1978) states that stomach contents of some young fish show one to ninety-five percent cladocerans by volume, and seldom less than ten percent. Furthermore, he states that increasing evidence shows that fish are selectively predacious on zooplankton populations by ingesting larger individuals in preference to smaller ones. Brooks and Dodson (1965) suggest that animals choose their food on the basis of its size, abundance, edibility, and the ease with which it is caught. Furthermore, natural selection will tend to favor the predator that most consistently chooses the largest food morsel available. They also suggest that when predation is intense, size-dependent predation will eliminate the larger forms allowing the smaller zooplankters (small cladocerans, nauplii and rotifers that escape predation) to become the dominants. The grazing pressure from

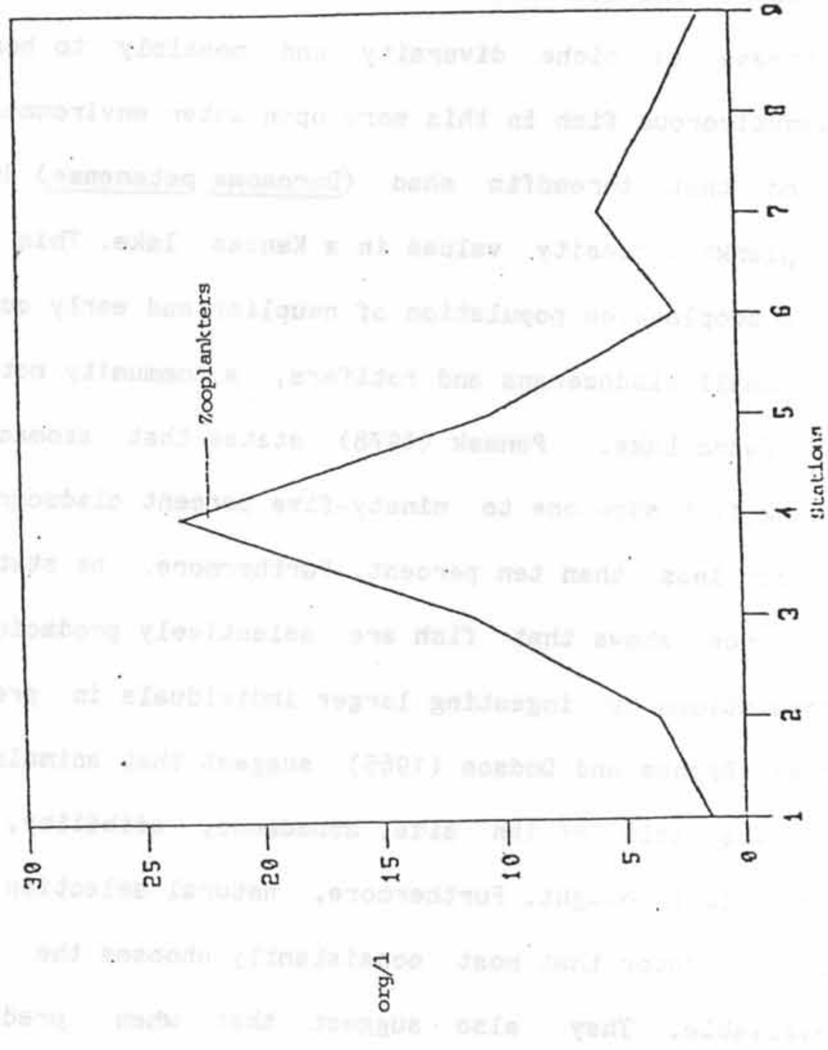

Figure 5. Annual mean of zooplankton community at each collecting station on Caddo Lake.

gizzard and threadfin shad at Caddo Lake appears to be very intense and is probably a major factor in the selection of small sized zooplankton species. Large planktivorous fishes are more selective on large zooplankters, because of the spacing of their gill rakers. The biomass of gizzard and threadfin shad (Dorosoma cepedianum and Dorsoma petenense) in Caddo Lake was estimated to be 926.9 lbs/acre during 1980, and 926 pounds of this biomass was gizzard shad in excess of eight inches. Therefore, these fish have a high reproductive potential, because the average size collected are out of the range of food items for most game fish in Caddo Lake (Joe Toole, Texas Parks and Wildlife, Marshall,Texas, personnel communication). This is a high standing crop for shad and is characteristic of a eutrophic reservior. Prichard (1976) estimated 817.5 lbs/acre of fish at eutrophic Livingston Reservoir, of which 586 pounds of biomass were threadfin shad. Zooplankters serving as a forage base for large numbers of planktivorous fish (eg: Dorosoma sp.) as well as from young piscivorous fish, along with the shallow basin at Caddo Lake (which limits vertical migration of zooplankton) may severely reduce the density of zooplankters during certain months of the year. The spawning season for the shad population at Caddo has been estimated to occur during April or May (Joe Toole, Texas Parks and Wildlife, Marshall, Texas, personnel communication). This may create an unusually high grazing pressure during the spring and could explain the absence of a spring zooplankton pulse.

The swamp region (stations 1, 2 and 3) was the next most productive region for the zooplankton community with an annual average of 15.0 org/l. The lower density value for this region may be due to its anoxic conditions during most of the summer months, and/or it may be due to the avoidance of highly vegetated areas. Hardy (1935) suggest that some algae may be capable of producing a toxic substance that inhibits zooplankters from grazing on them. Porter (1977) hypothesized that the "principle of animal exclusion" originally suggested by Hardy in 1935, may not be the reason for zooplankton avoidance of heavily vegetated areas. Instead, she suggests that the lower numbers there may be due to the physical impediment and its relationship with energy expenditure. In addition to the effects of excessive aquatic vascular plant biomass in the swamp region, low dissolved oxygen values may have contributed also to lower zooplankton numbers. Hutchinson (1967), Pennak (1978) and Reid and Wood (1976) all state that anoxic conditions can cause detrimental effects to the zooplankton community.

The oil producing region (stations 8 and 9) was the least productive of all the regions with an annual average of 4.0 org/l. The low productivity in this region may be due to pollution from offshore oil wells and by grazing from Chaoborus larvae. Goulden (1971) Nordlie (1978) Pennak (1978) and Ellsworth (1983) reported that Chaoborus larvae are opportunistic predators which feed on planktonic crustacea and may significantly reduce their numbers in the zooplankton community. Thomas Cusack (personnel communication, 1983) in a study of the benthic community of Caddo Lake, found an annual mean density value of Chaoborus punctipennis in this region to be 3,821 org/meter square, an unusually high population. The mean values for the swamp and open water regions were 546 and 2,230 org/meter square, respectively. Furthermore, he also concluded that the emergence of the Chaoborus occurred during May. It is interesting to note that the zooplankton numbers (particularly the cladocerans) at stations 8 and 9 increased during this same period.

During the fall, the most productive season, the dominants were: Chydorus sphaericus, Simocephalus serrulata, Platyias patulus, Brachionus angularis, Platyias quadracornis, Asplanchna sp., Bosmina longirostris, Cyclops bicuspidatus and Notommata sp. The winter dominants include: Chydorus sphaericus, Keratella cochlearis and Bosmina longirostris. During the spring, Chydorus sphaericus, proved to be the most abundant species; Bosmina longirostris was the next most abundant; followed by Keratella cochlearis, Simocephalus serrulata and Notommata sp. The summer dominants were: Diaptomus siciloides, Bosmina longirostris, Simocephalus serrulata, Platyias patulus, Brachionus angularis and Asplanchna sp. (Figures 6, 7, 8 and 9).

Zooplankton Community By Regions:

Figure 10 illustrates the annual mean zooplankton density for each region. The "open water region" was the most productive for the zooplankton populations and the oil producing region was the least. Figure 11 shows the regional mean zooplankton values for the major taxa. For the most part, the open water region was the most productive for each major taxa and the oil producing , was the least. The overall order of dominance for the major taxa were: immature copepods, cladocerans, rotifers and adult copepods.

Swamp:

The swamp region encompassed stations 1, 2 and 3 and had an intermediate zooplankton production value. for the zooplankton community. Figure 12 shows the annual means for the major taxa at each station. The general trend at these stations was a progressive increase in zooplankton density toward the open water region, which was also the direction of water flow. Station 1 was a riverine site that received periodic turbulent flow. This station had one of the lowest annual means of all the stations (Table 3). Station 2 was a transitional zone from a riverine to a swamp environment. Aquatic macrophytes were prolific at this station, however, anoxic conditions were seldom observed. Station 3 was a swamp environment and during the summer, dense mats of aquatic vascular plants covered the entire water surface and resulted in anoxic conditions during periods of darkness. Figure 13 gives the generic means for the dominants in the swamp region. Chydorus sphaericus, Keratella cochlearis, Sida sp. and Diaptomus siciloides dominated the swamp region annually.

Open:

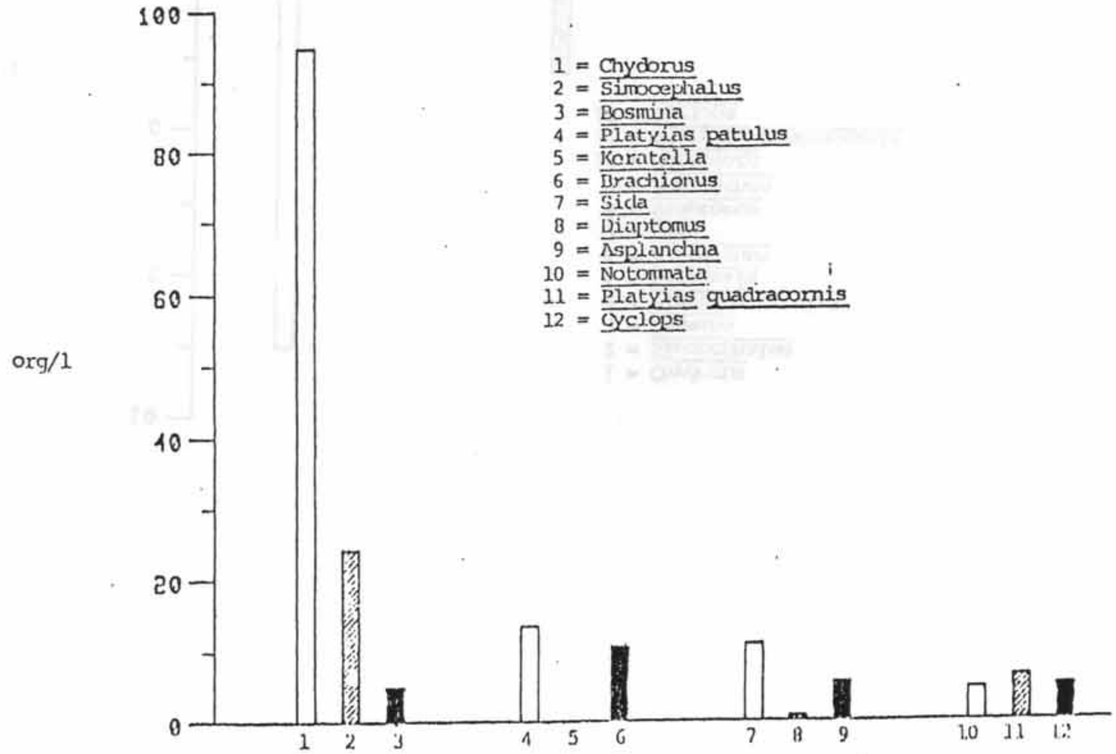

Figure 6. Total numbers organisms (org/l) of selected genera during the fall season at Caddo Lake.

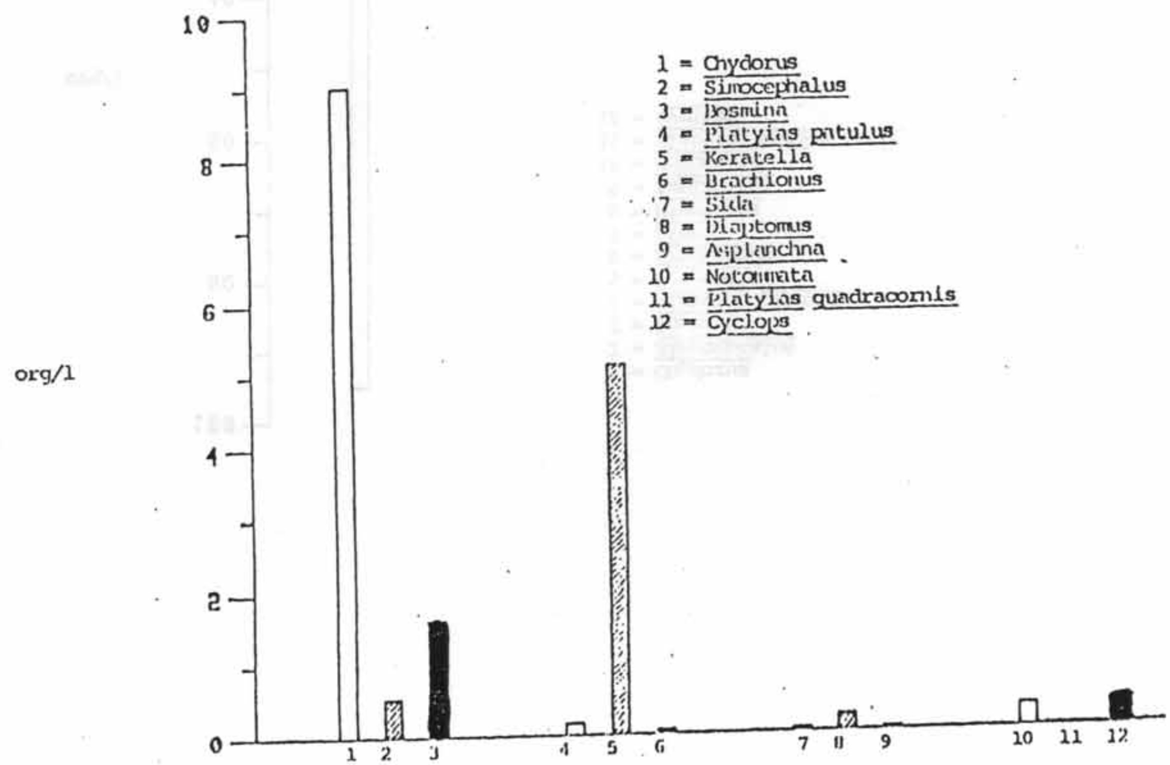

Figure 7. Total numbers of organisms (org/l) of selected genera during the winter season at Caddo Lake.

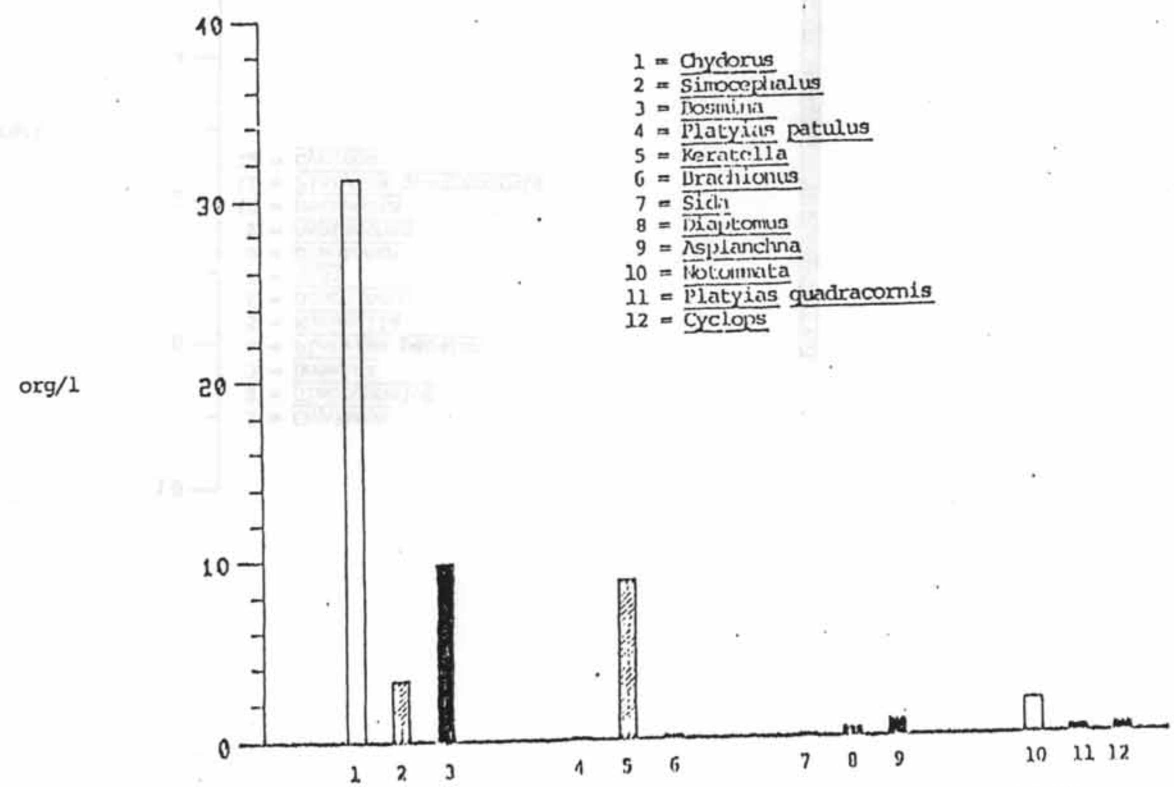

Figure 8. Total numbers of organisms (org/1) of selected genera during the spring season at Caddo Lake.

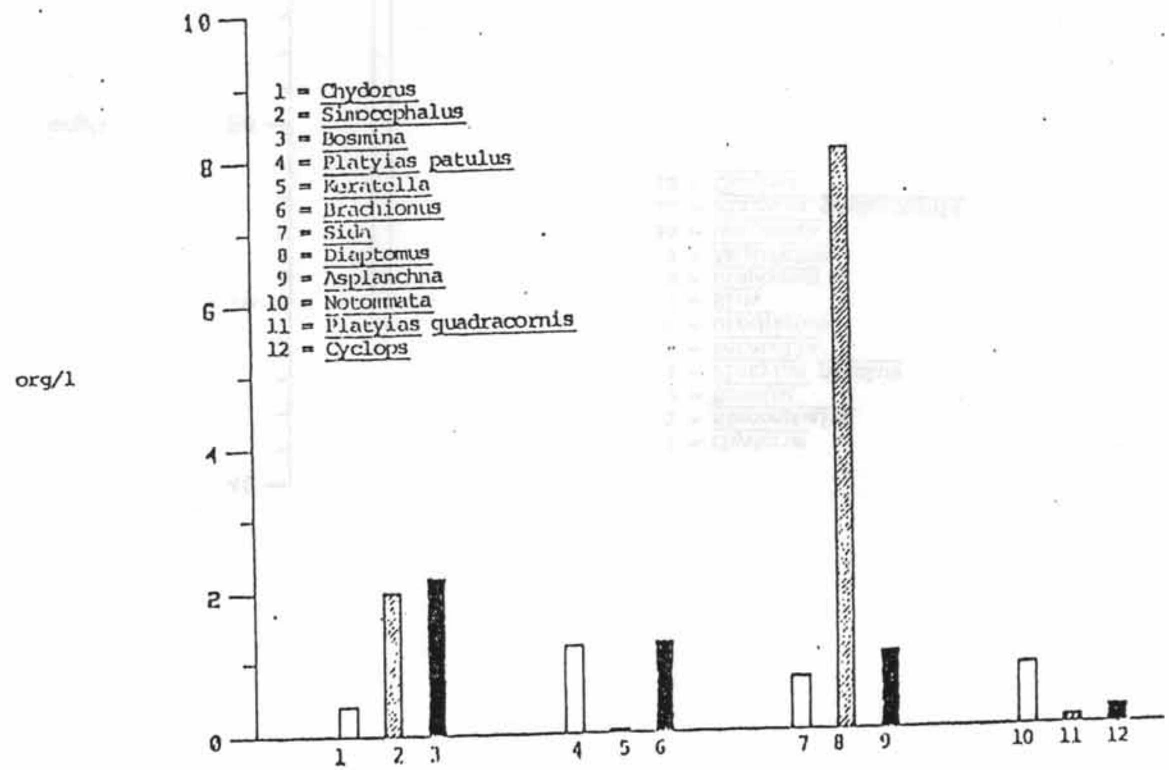

Figure 9. Total numbers of organisms (org/l) of selected genera during the summer season at Caddo Lake.

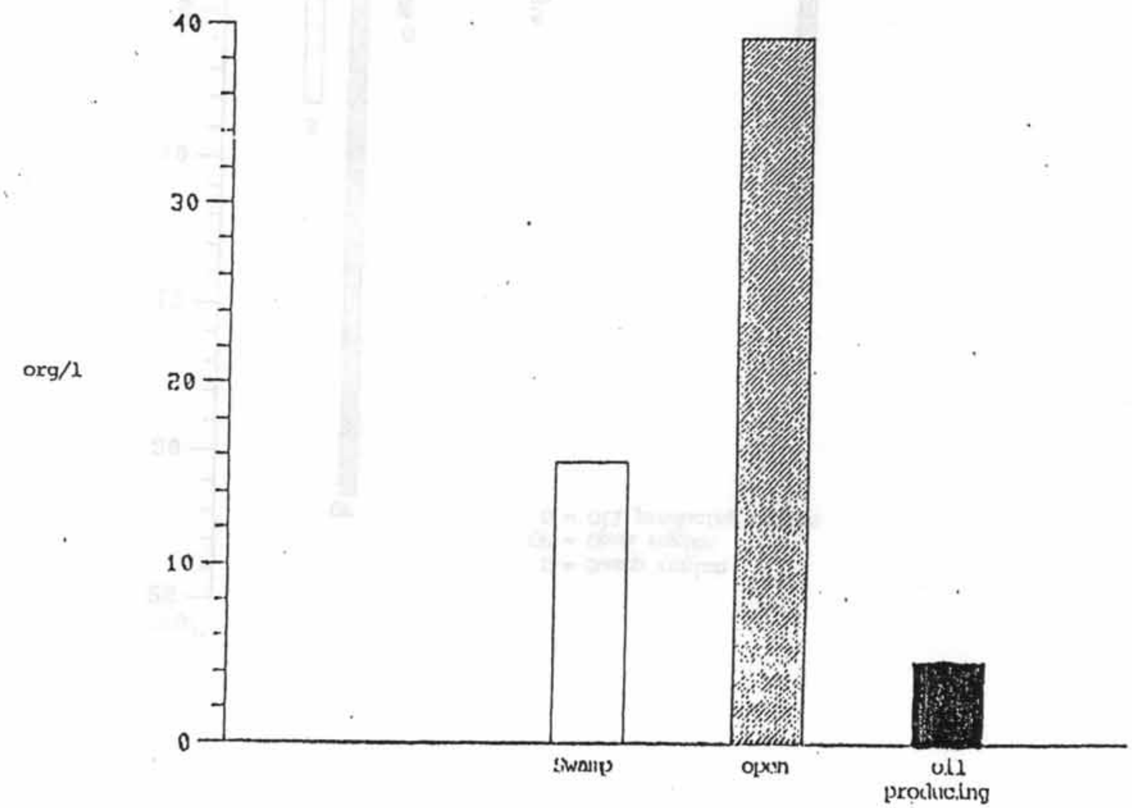

Figure 10. Regional zooplankton density mean during the sampling period at Caddo Lake.

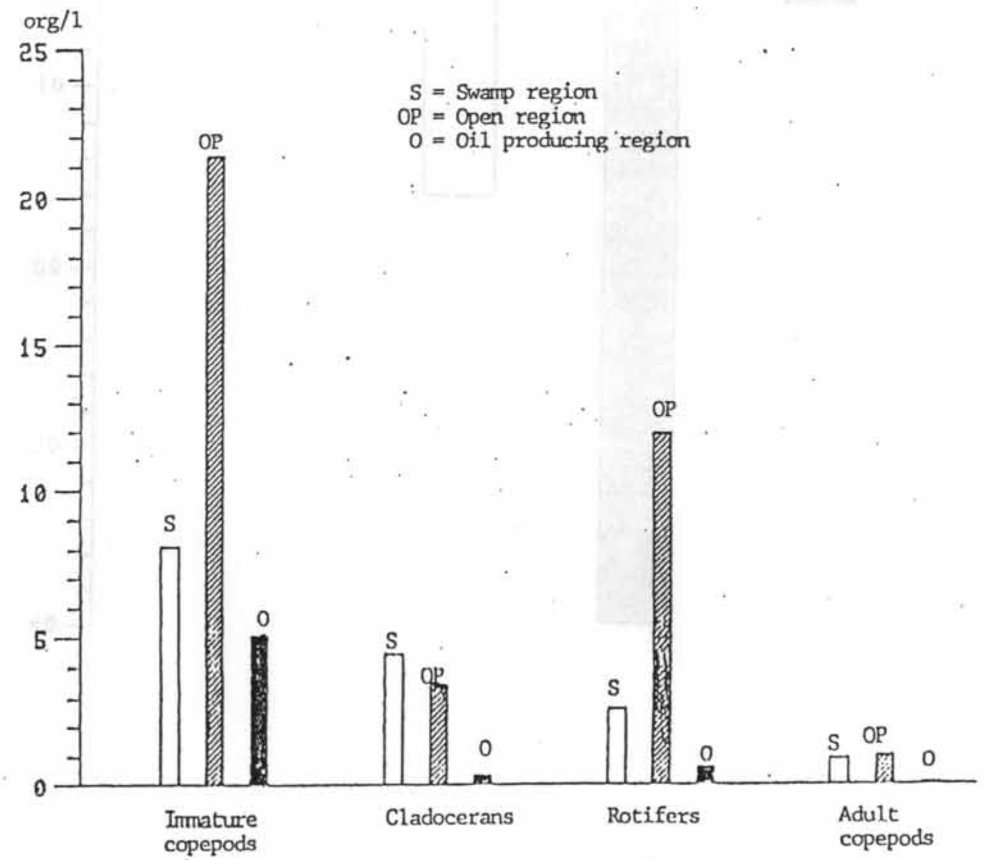

Figure 11. Regional zooplankton means for each major taxon at Caddo Lake.

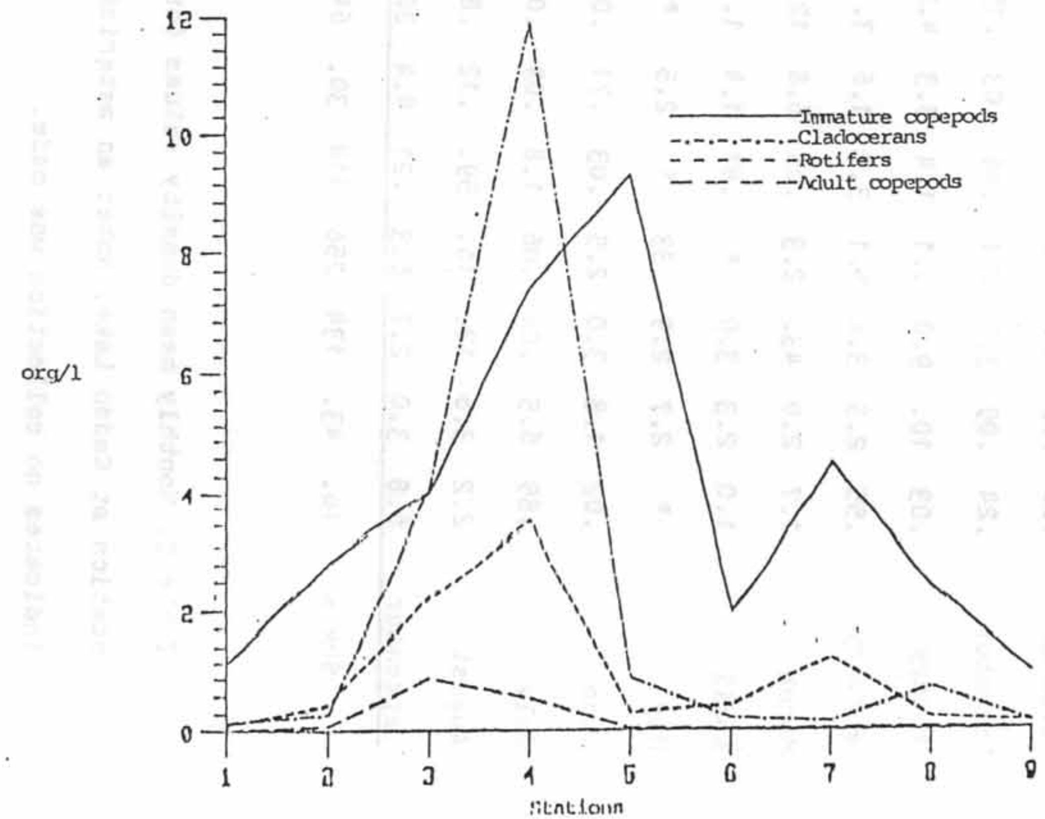

Figure 12. Annual mean zooplankton density for the major taxa (org/l) at each station at Caddo Lake.

MONTH	STATIONS 1	2	3	4	5	6	7	8	9
October	1.9	1.0	33.	168	29.	5.0	17.	9.0	2.6
November	1.6	7.5	16.	46.	17.	2.8	4.5	4.2	1.2
December	.24	.09	3.5	.21	.46	.03	.15	.85	.50
January	.03	10.	9.0	5.1	1.4	5.3	4.2	.07	.93
February	.55	2.5	3.8	5.1	3.2	1.6	3.1	.81	.12
March	1.7	2.0	43.	2.3	.06	6.8	12.	3.1	.71
April	1.0	2.3	3.9	*	.67	1.4	1.4	.15	1.6
May	*	2.7	2.9	.33	*	2.5	*	11.	2.0
June	.02	1.8	3.0	2.5	.03	.71	.02	1.0	.03
July	.85	6.5	.06	.06	1.8	.09	.06	.67	.03
August	2.2	3.6	12.	16.	59.	.12	.87	2.3	3.5
September	6.8	3.0	2.7	8.3	.21	4.4	20.	6.4	1.2
SUM =	16.	43.	134	256	114	30.	64.	40.	14.

Table 3. Monthly mean density values (org/l) for each station at Caddo Lake. Note: an asterisk indicates no collection was made.

Stations 4, 5, 6 and 7 were designated the open water region. Figures 12 illustrates the zooplankton trends in this region. Flow in this region was from station 4 to station 6. Station 7 received its flow from the oil producing region and from station 6. Station 4 was a highly productive transitional zone from a swamp to a lacustrine environment. A large amount of niche diversity existed at this station during the summer due to the large number of aquatic macrophytes (Nelumbo lutea, Nymphea odorata, Egeria sp., Hydrilla sp. and Myriophyllum sp.).This station experienced no anoxic conditions during the sampling period. Station 5 had less niche diversity than that of station 4; only submergent aquatic vascular plants were found at this station (Hydrilla sp., Myriophyllum sp. and Egeria sp.). Station 6 had very little aquatic vascular plant growth, therefore, niche diversity decreased. Station 7 had no floating or submergent aquatic vascular plants, and this station was in a region of sparce oil production. The open water region was dominated by the following : immature copepods, rotifers, cladocerans and adult copepods, respectively. The absence of large zooplankters in this region may reflect the grazing pressure from planktivorous fish. The smaller species replaced the larger cladocera and copepods. The generic dominants of the open water region are illustrated in Figure 14. The dominant taxa at each station were also determined. Station 4 was dominated by Chydorus, Simocephalus, Platyias patulus, Sida, Diaptomus, Cyclops, Notommata, Bosmina, Asplanchna and Brachionus. Station 5 had the following dominants:

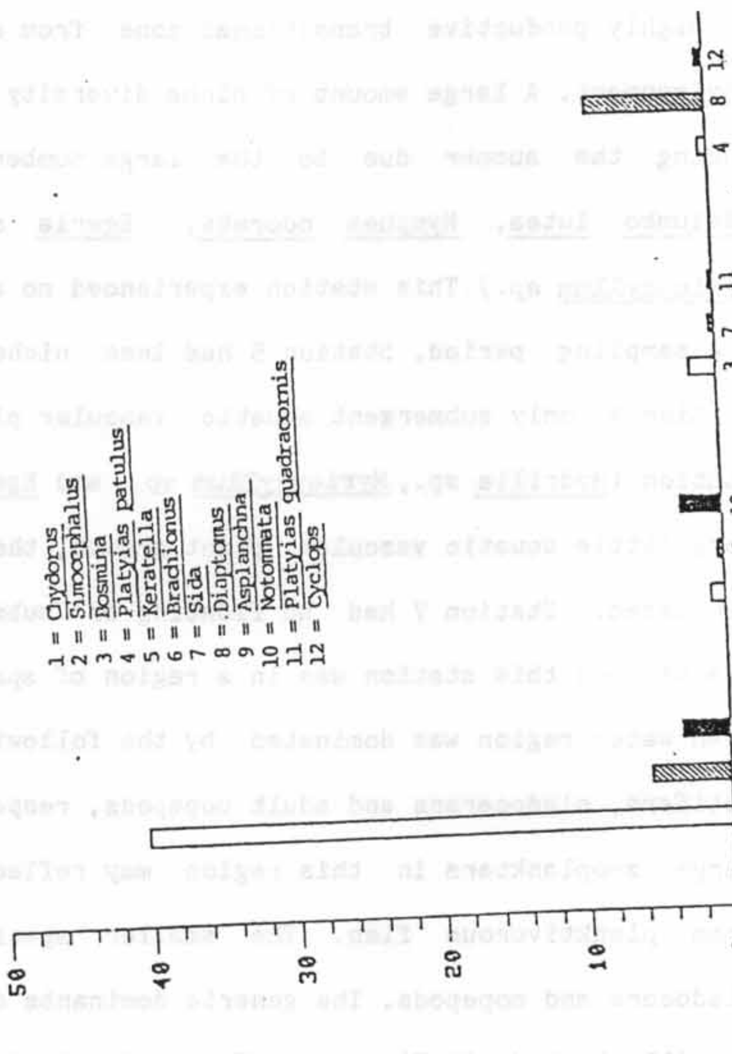

Figure 13. Total numbers of organisms (org/1) of selected genera for the swamp region at Caddo Lake.

Simocephalus and Bosmina. Station 6 and 7 had only Brachionus and Keratella as dominants. Again, the smaller species were more common which may reflect more intense grazing pressure by fish populations. Furthermore, station 4 was dominated by littoral benthic feeding species of cladocera and copepods, which decline in numbers with the decrease in aquatic vascular plants at stations 5 and 7.

Oil Producing:

The oil producing region consisted of stations 8 and 9. Water flow in this region was from station 9 to station 8. The oil producing region consistently showed lower zooplankton density values than those of the other two regions with an average annual zooplankton density value of 4.6 org/l (Figure 10). Figures 12 and 13 shows a general increase in zooplankton numbers progressing from station 9 to station 7. This increase in numbers could be related to a dilution effect of chlorides from stations 8 and 9, as the open water region is approached (Figure 15) and/or a decrease in predacious dipteran larvae. The comparison of chloride concentrations and the rotifer numbers suggests that the rotifer community is adversely effected by chloride concentrations. Rogers (1976), Hutchinson (1967), Ruttner-Kolisko (1974) and Pennak (1978) all report numbers to be reduced by small increases in chloride values. However, Ruttner-Kolisko (1974) found two species of Brachionus occurring in waters with relatively high chloride concentrations. The low crustacean numbers in the oil producing region may be due to heavy

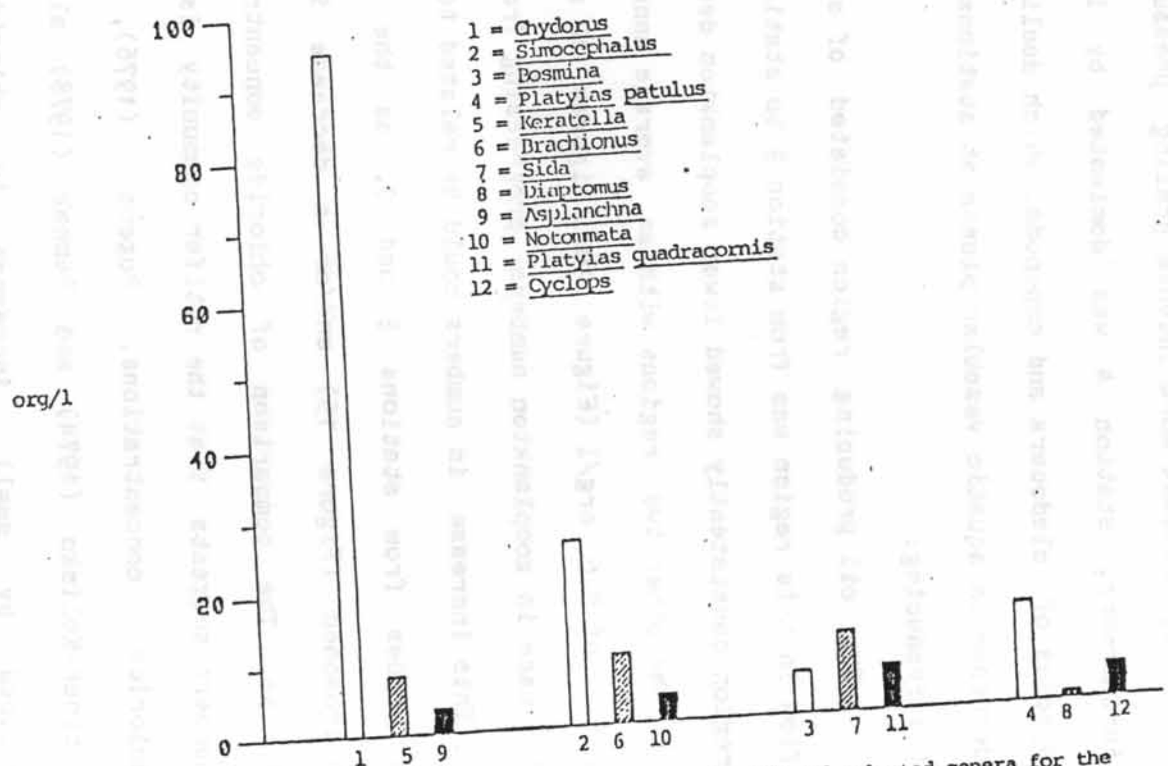

Figure 14. Total numbers of organisms (org/l) of selected genera for the open water region at Caddo Lake.

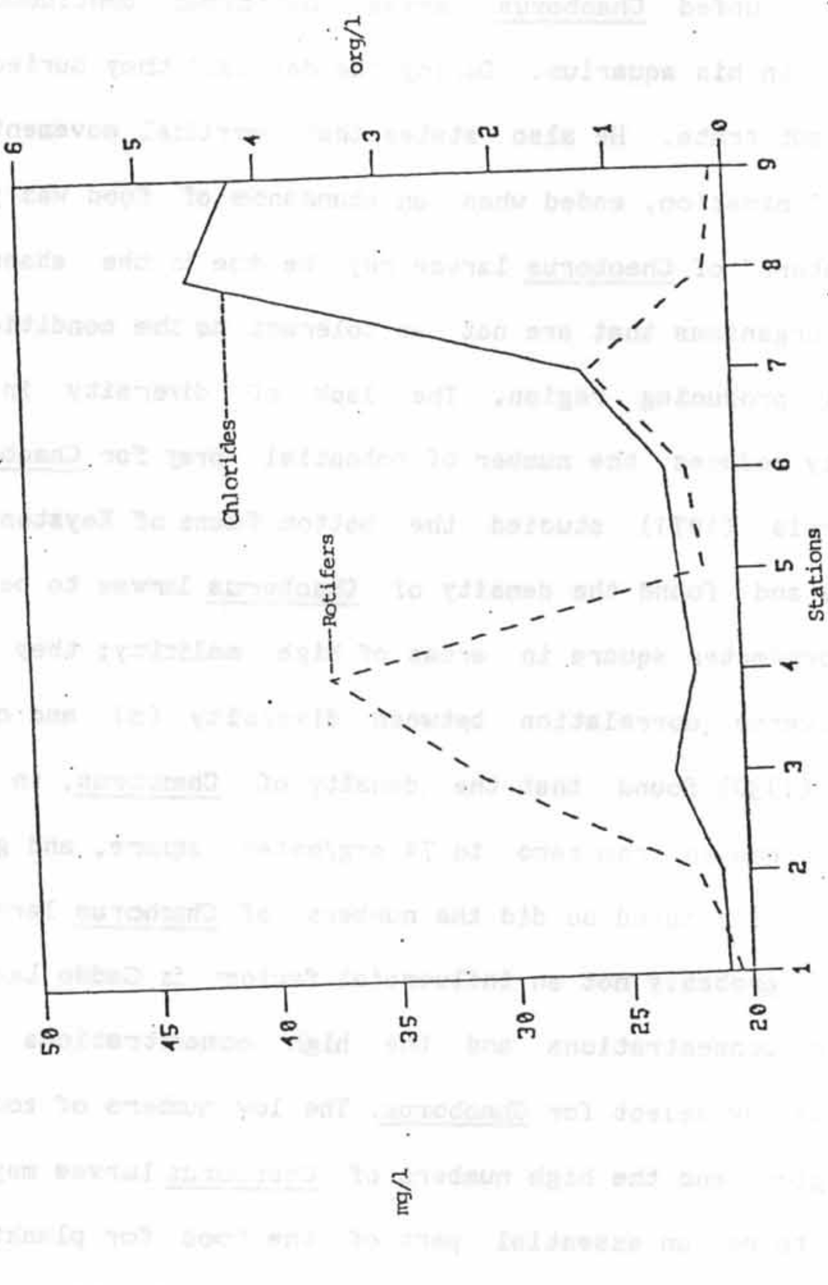

Figure 15. The mean chloride concentrations and mean numerical density of rotifers at each station at Caddo Lake.

predation from predacious dipteran larvae. Berg (1937) found that in darkness, unfed Chaoborus larvae performed continuous vertical movements in his aquarium. During the daylight they buried themselves in the substrate. He also states that vertical movement, dependent upon illumination, ended when an abundance of food was present. The high numbers of Chaoborus larvae may be due to the absence of other benthic organisms that are not as tolerant to the conditions found in the oil producing region. The lack of diversity in the benthic community reduces the number of potential prey for Chaoborus. Ransom and Dorris (1971) studied the bottom fauna of Keystone Reservoir, Oklahoma and found the density of Chaoborus larvae to be as high as 2,512 org/meter square in areas of high salinity; they also found a high inverse correlation between diversity (d) and conductivity. Rawson (1930) found that the density of Chaoborus, in Lake Simcoe, Ontario, ranged from zero to 74 org/meter square, and generally, as the depth increased so did the numbers of Chaoborus larvae; however, depth is probably not an influencial factor in Caddo Lake. Here, the chloride concentrations and the high concentrations of crude oil fractions may select for Chaoborus. The low numbers of zooplankters in this region and the high numbers of Chaoborus larvae may cause these larvae to be an essential part of the food for planktivorous fish populations in this region. Reid (1961) and Hutchinson (1967) state that dipteran larvae can play important roles in the food for fishes. The dominant zooplankters for the oil producing were: Bosmina longirostris and Brachionus angularis (Figure 16).

Variations in the numbers of zooplankton throughout the sampling period were not significantly correlated with variations in any of the physico-chemical parameters analyzed.

Community Ordination

Figure 17 contains the results from an annual community ordination and three associations in community structure are suggested. These associations were disjunct from one another by numerical density and the species present. Stations 1 and 9 formed the first group, which had the lowest zooplankton density. The low densities are reflected by the relatively high similarity coefficient (0.84). The low numbers at station 1 is probably caused by turbulent flow in Cypress Bayou, while the effect of the offshore oil wells at station 9 may have reduced numbers there. The second group consisted of stations 6, 7, 8 and 2. These stations had intermediate densities. With the exception of station 2, they were open water zones. The third group (stations 3, 4 and 5) had the highest densities and were located in the swamp or transition zones.

Species Diversity

Over the sampling period, 42 species of zooplankters were collected including the rare rotifer Trochosphaera solstitalis and the

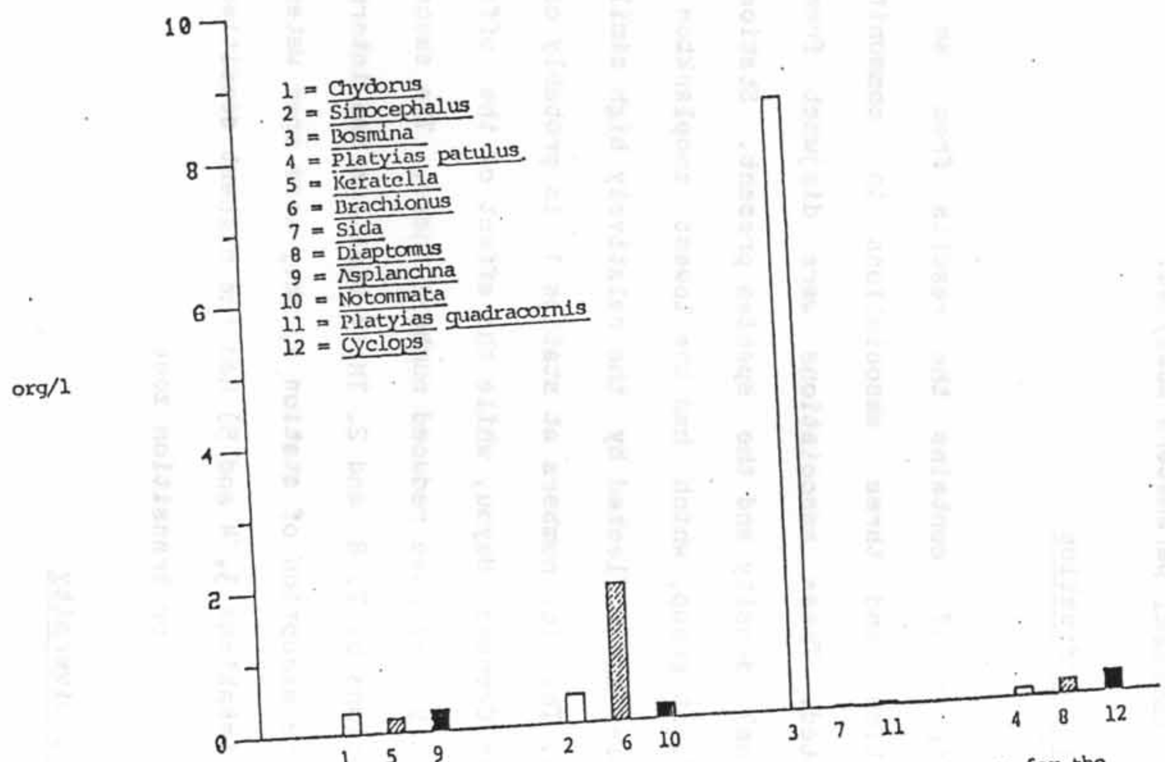

Figure 16. Total numbers of organisms (org/l) of selected genera for the oil producing region at Caddo Lake.

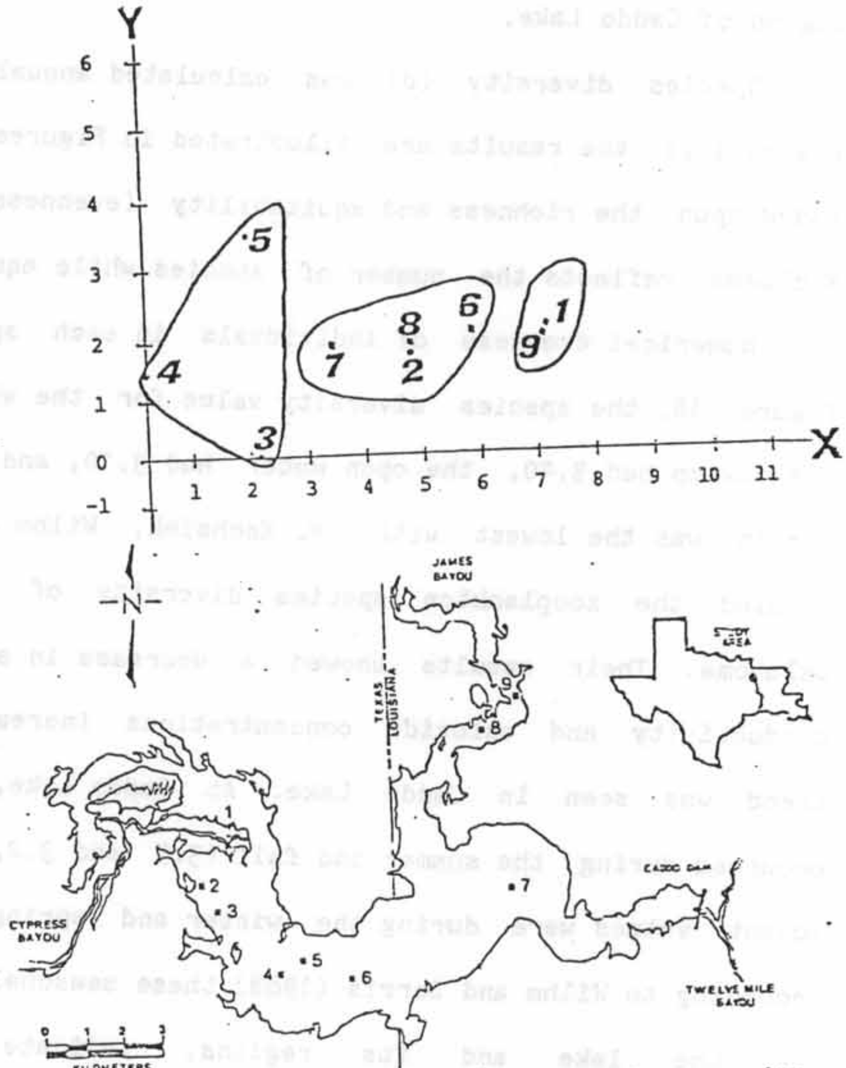

Figure 17. Annual community ordination of the zooplankton community structure at Caddo Lake.

rare cladoceran Bosminopsis detersei (Table 1). Of those 42 species, 41 were found in the swamp region, 39 of those species were collected in the open water region, while only 32 occurred in the oil producing region of Caddo Lake.

Species diversity (d) was calculated annually, seasonally and regionally; the results are illustrated in Figures 18 and 19. It is based upon the richness and equitability (evenness) in a population. Richness reflects the number of species while equitability reflects the numerical evenness of individuals in each species. As shown in Figure 18, the species diversity value for the whole lake was 3.41, the swamp had 3.40, the open water had 3.10, and the oil producing region was the lowest with 2.4. Kochsiek, Wilhm and Morrison (1971) studied the zooplankton species diversity of Keystone Reservoir, Oklahoma. Their results showed a decrease in species diversity as conductivity and chloride concentrations increased, and a similar trend was seen in Caddo Lake. At Caddo Lake, the highest values occurred during the summer and fall (3.5 and 3.2, respectively). The lowest values were during the winter and spring with 2.9 and 2.6. According to Wilhm and Dorris (1968) these seasonal and annual values, for the lake and its regions, indicate the lake is an oligo-mesotrophic environment. Those values may reflect the high habitat diversity rather than the trophic state. A better indicator of the true trophic state of the lake may be the dominant organisms and/or the monthly and annual stational species diversity values

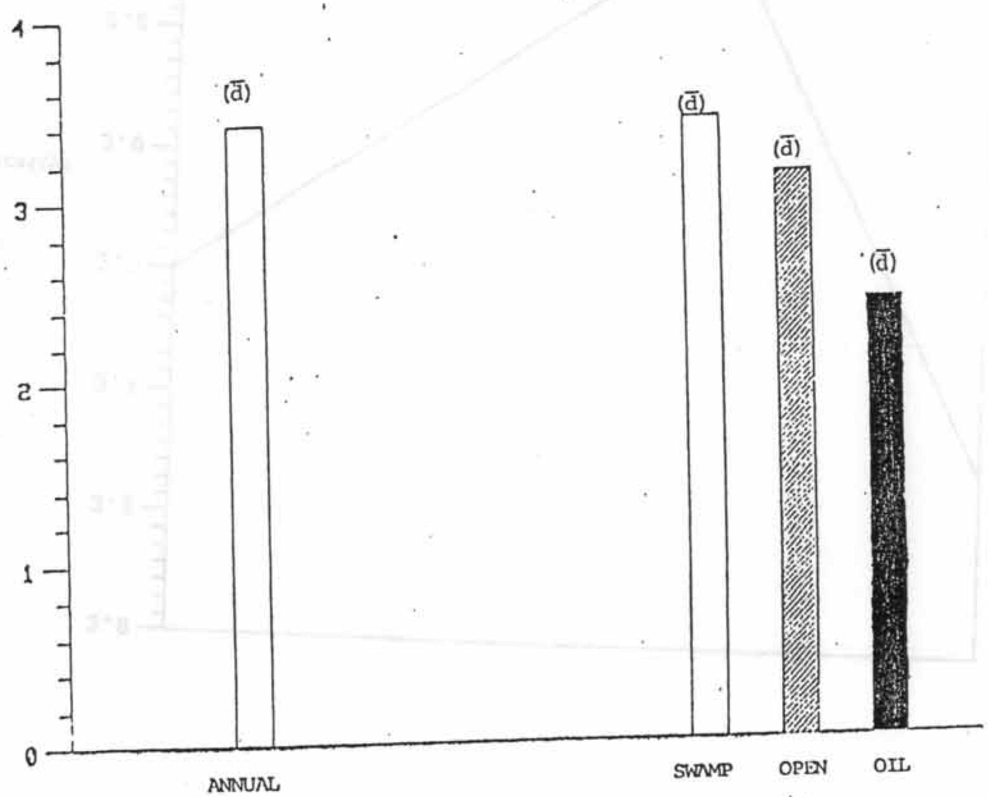

Figure 18. The average zooplanton species diversity index for Caddo Lake and for each region of Caddo Lake.

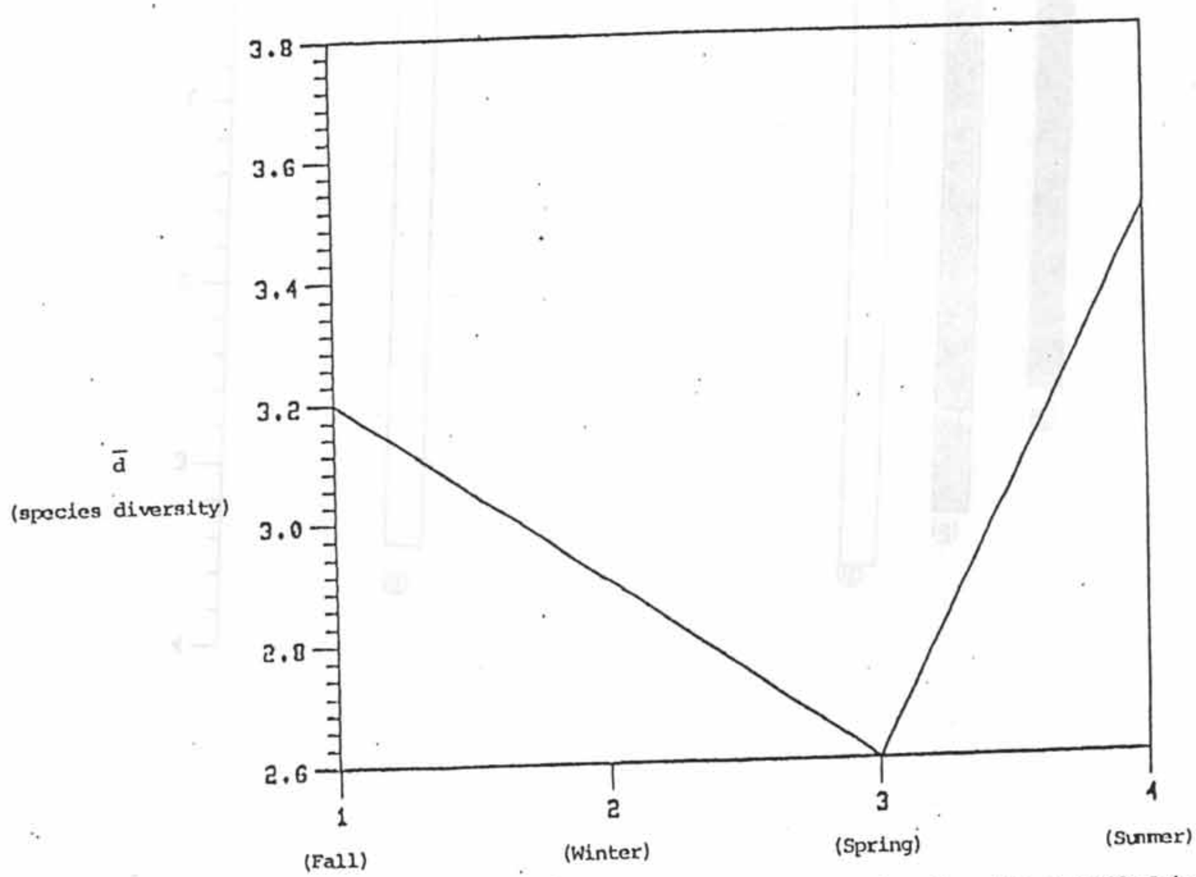

Figure 19. Seasonal trends in zooplankton species diversity at Caddo Lake.

(Tables 4 and 5). The yearly means for each station ranged from 1.42 at station 8 to 2.21 at station 2. From the values listed in Table 5, Caddo is a mesotrophic lake tending toward eutrophy. The eutrophic classification is also supported by the dominant species found in the lake during the sampling period (Table 1). Gannon and Stemberger (1978) list species of zooplankton which indicate eutrophy and includes: Bosmina longirostris (a cladoceran) and the rotifer genera Brachionus, Filinia, Keratella, Polyarthra, Tricocerca, Conochiloides, Anuracopsis, and Pompholyx. Only Anuracopsis was absent here.

Table 5 gives the yearly mean species diversity values by station in increasing order of magnitude. The lowest values were once again, areas associated with offshore oil production. Station 1 was a riverine station that received periodic turbulent flow. Stations 5 and 6 were next, both of these stations were open water stations. The low values of station 5 and 6 may be due to grazing by planktivores. Stations 2, 3 and 4 were highly vegetative areas containing a prolific growth of aquatic macrophytes, both emergents and submergents. Regional trends in diversity shows the swamp stations with the higher species diversity, followed by the lacustrine then the riverine stations. The three stations in associations with oil production (two semi-riverine and one lacustrine station) exhibited the lowest species diversity values (Table 5). The lower diversity values in the oil producing region may be due to predation pressure from planktivores, dipteran larvae and/or toxicants from offshore oil production (eg:

		STATIONS									
SEASON	MONTH	1	2	3	4	5	6	7	8	9	X(mo)
FALL	SEPT.	2.3	2.2	1.6	2.9	1.4	1.7	.91	1.7	2.8	1.9
FALL	OCT.	2.2	2.5	3.3	1.9	2.3	2.1	2.3	.86	1.8	2.1
FALL	NOV.	.60	3.6	1.4	2.6	1.5	2.1	1.4	.67	2.5	1.8
WINT	DEC.	1.5	1.6	2.3	1.1	1.0	.92	2.2	.97	1.0	1.4
WINT	JAN.	.81	3.2	1.4	.69	2.4	2.7	1.8	1.4	.92	1.7
WINT	FEB.	.84	1.0	1.4	2.8	.88	2.2	2.7	1.5	3.2	1.8
SPRG	MAR.	2.0	1.2	1.5	2.5	1.0	1.9	1.6	1.8	2.3	1.8
SPRG	APR.	.92	2.4	2.4		2.7	2.0	2.0	2.7	1.4	2.1
SPRG	MAY		2.3	2.3	2.1		2.2		1.1	.53	1.8
SUMM	JUNE	2.2	1.2	2.6	2.0	0.0	0.0	0.0	1.6	0.0	1.1
SUMM	JULY	1.4	2.8	1.0	0.0	2.3	1.6	1.5	1.0	0.0	1.3
SUMM	AUG.	2.5	2.5	.58	2.7	2.6	2.0	.63	2.2	2.2	2.0
	X(yr)	1.6	2.2	1.8	1.9	1.6	1.7	1.5	1.4	1.5	
		SWAMP				OPEN			OIL		

Table 4. Monthly species diversity values, by station, for Caddo Lake during the sampling period.

STATIONS	$\bar{d}$ (yr)	REGIONS/ENVIRONMENTS
#8	1.43	Oil/semi-riverine
#7	1.54	Open/lacustrine
#9	1.55	Oil/semi-riverine
#1	1.57	Swamp/(strict) riverine
#5	1.65	Open/lacustrine
#6	1.78	Open/lacustrine
#3	1.81	Swamp/highly vegitative
#4	1.94	Open/highly vegitative
#2	2.21	Swamp/highly vegitative

Table 5. Annual species diversity, for each station, at Caddo Lake (listed from the lowest to the highest value).

chlorides and hydrocarbons).

The highest monthly mean for species diversity occurred in October with 2.14. The lowest monthly value was obtained in June with 1.06 (Tables 4 and 5).

<u>Major Taxa Of Caddo Lake:</u>

Immature Copepods:

The immature copepods were the most numerous (64.5%) of the zooplankton groups and their numbers were significantly higher during the fall (Table 6). The domination of the zooplankton community by naupliar and copepodite stages of copepods may indicate the selection of larger zooplankters from planktivorous fish populations.

Adult copepods:

The adult copepods were respresented in very low numbers throughout the sampling period. They comprised only 2.1% of the annual zooplankton collected. Results from a 2-Way ANOVA revealed a significant interaction (90% Confidence Level) between the adult copepod population with stations and seasons (Table 7). Station 4 was the most productive during the fall season and station 3 was the most productive for these organisms during the summer. Two species of adult copepods dominated the zooplankton community, <u>Cyclops bicuspidatus</u> and <u>Diaptomus siciloides</u>. <u>Cyclops bicuspidatus</u>, a predacious copepod, occurred most often at station 4 during the fall season. <u>Cyclops</u> sp. is commonly found in warm subtropical and temperate regions (Pennak 1978). <u>Diaptomus siciloides</u>, a herbacious copepod, occurred most often

Source	D.F.	SS	MS	F	P
Main effects	11	546.747	47.704	3.84	<.000
Stations	11	165.530	20.691	1.59	.143
Seasons	3	384.845	128.28	9.91	<.000
Interaction	24	398.915	16.621	1.28	.212

SEASONS:

Winter	Spring	Summer	Fall
1.6118	1.9201	3.6218	7.6043

Table 6. A 2-Way Analysis of Variance and Duncan's Multiple Range Test of immature copepods with stations and seasons at Caddo Lake.

Source	D.F.	SS	MS	F	P
Main effects	11	.496	.045	1.71	.090
Stations	11	.398	.050	1.89	.077
Season	3	.114	.038	1.44	.237
2-Way interaction	24	1.228	.051	1.94	.018
STATIONS/SEASONS	24	1.228	.051	1.94	.018

Table 7. Analysis of Variance (2-Way) of adult copepods with stations and seasons at Caddo Lake.

at station 3 during the summer months. Diaptomus siciloides has been reported from a broad variety of habitats and they seem to have a wide niche width which would cause the species to be ideally suited for this highly variable environment (Hutchinson 1967). The appearance of these two organisms during different seasons prevents them from competing. Furthermore, according to Hutchinson (1967) Cyclops sp. usually reproduce during the winter and go through diapause during the summer. Reproductive season for Diaptomus sp. is generally during the summer season (Hutchinson 1967). Because of the broad niche tolerances exhibited by various species of Diaptomus, toleration of anoxic conditions during the summer months at Caddo probably reduced the predation pressure from planktivorous fish populations.

Cladocerans:

The cladocerans comprised 22.8% of the annual zooplankton community. Generally, the fall season was the most productive for this taxon and the most productive region was the swamp. Reid and Wood (1976) suggest that nearly all species of Chydoridae (which are common in Caddo Lake) are found in stable embayments or backwaters. The cladoceran community was annually dominated by: Chydorus sphaericus, Simocephalus serrulata, Bosmina longirostris and Sida sp. (Figure 20). According to Hutchinson (1967) Chydorus sp., Bosmina longirostris and Simocephalus sp. are typically benthic feeding organisms found in shallow, warm-water, but are capable of existing in a variety of habitats.

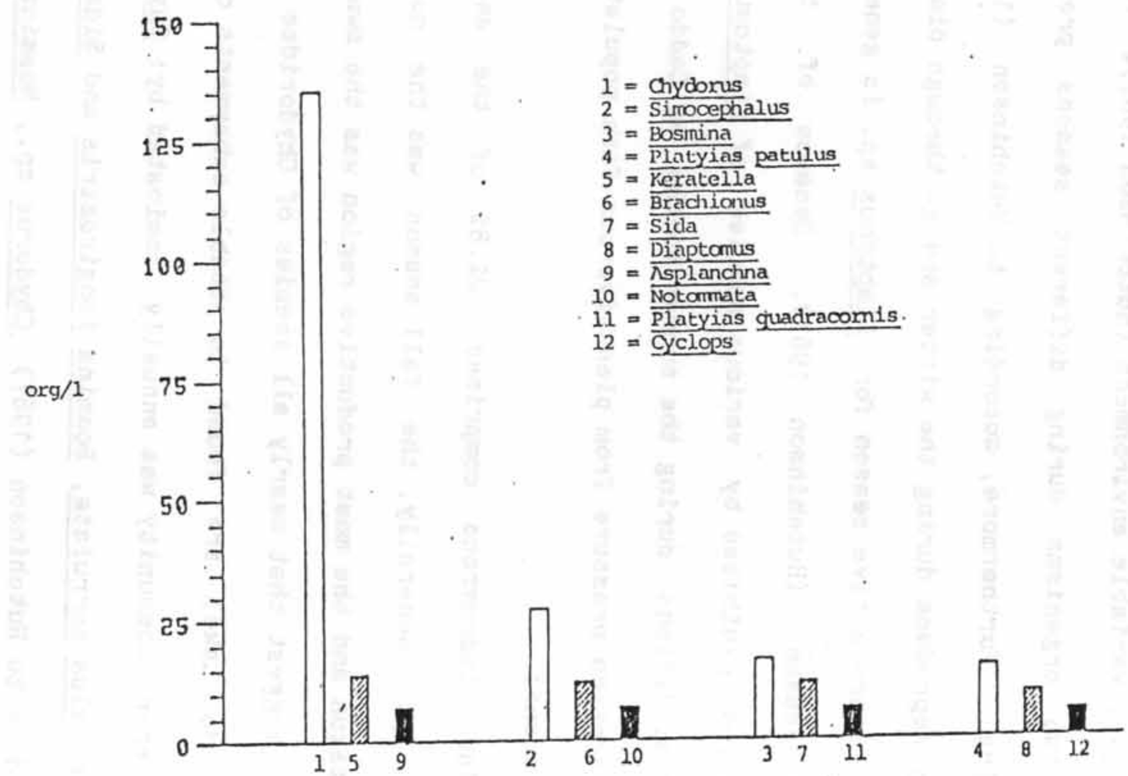

Figure 20. Total numbers of organisms (org/l) of selected genera for the sampling period at Caddo Lake.

Rotifera:

Figures 11 and 21 show the fall season and the open water region as being the most productive for this taxon. Annually, the rotifers comprised 10.8% of the total zooplankton community collected during the sampling period. Table 8 illustrates a significant difference in rotifer density at stations 1, 8 and 9 from station 7. Stations 1, 8 and 9 were the least productive stations for this taxon, while station 7 was the most productive. Significantly higher (95% Confidence Level) rotifer populations occurred during the fall. The dominant rotifers during the study period include: Platyias patulus, Keratella cochlearis, Brachionus angularis and Asplanchna sp. These organisms are generally considered to be eurytopic taxa with wide niche tolerances. According to Hutchinson (1967) Brachionus sp. and Keratella sp. are eutrophic indicators capable of inhabiting a variety of environments. Gannon and Stemberger (1978) state that Brachionus sp., Platyias sp. are common indicators of eutrophic conditions. Pennak (1978) and Ruttner-Kolisko (1974) state that Keratella sp., Asplanchna sp. and Brachionus sp. are cosmopolitan organisms. Also according to Ruttner-Kolisko (1974) Brachionus sp., Keratella quadrata, and Keratella cochlearis are generally found in shallow waters; he also states that Keratella cochlearis is a eutrophic indicator.

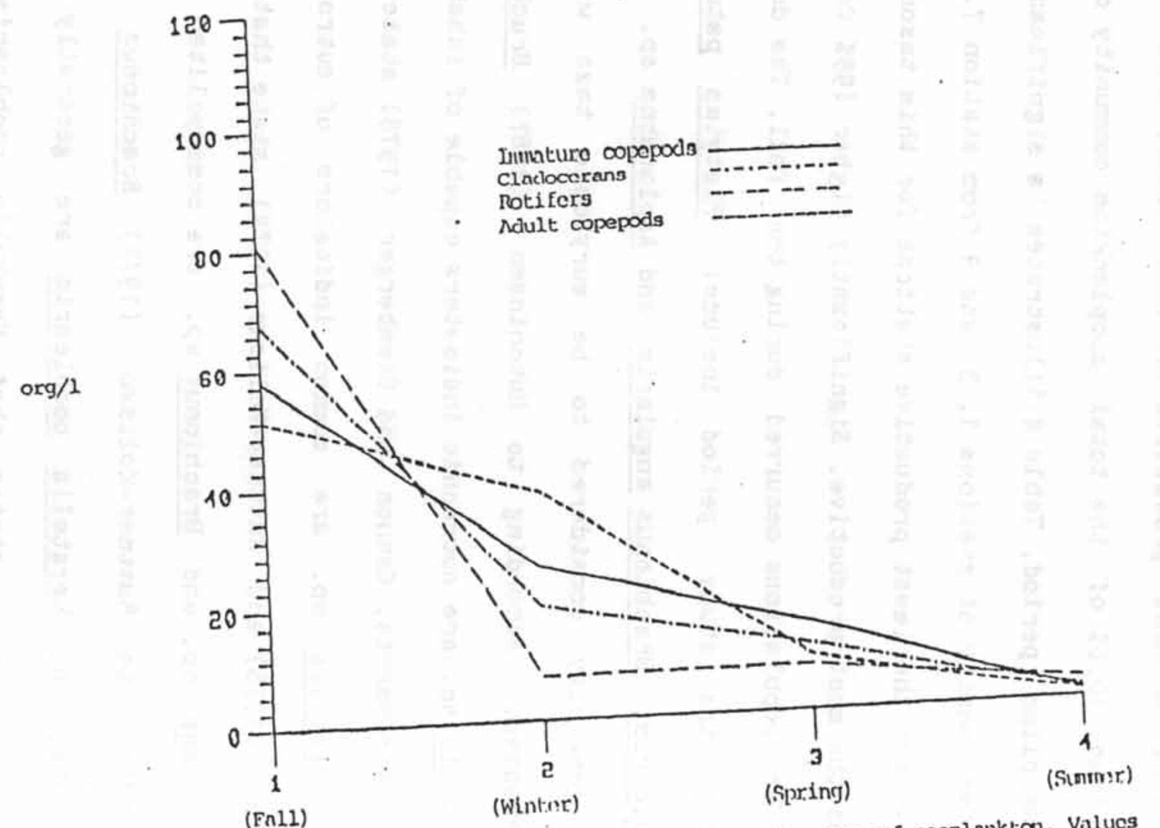

Figure 21. Seasonal percentages for the major taxa of zooplankton. Values are based on the total number of zooplankters collected during the sampling period at Caddo Lake.

Source	D.F.	SS	MS	F	P
Main effects	11	26.261	2.383	2.45	.012
Stations	11	16.492	2.062	2.13	.045
Season	3	10.655	3.552	3.67	.017
Interaction	24	27.803	1.158	1.19	.277

SEASONS:

Winter	Spring	Summer	Fall
0.252	0.253	0.624	2.5691

STATIONS:

0.093	0.123	0.214	0.298	0.412	0.429	0.942	1.030	(MEANS)
1	9	8	5	6	2	3	4	(STATIONS)

(MEANS)	.2989	.4129	.4293	.9420	1.0302	1.2204
(STATIONS)	5	6	2	3	4	7

Table 8. A 2-Way Analysis of Variance and Duncan's Multiple Range Test of rotifer populations with stations and seasons for Caddo Lake.

THE CADDO LAKE ZOOPLANKTON COMMUNITY:

SUMMARY AND CONCLUDING STATEMENTS.

Generally, the dominant organisms at Caddo Lake are littoral organisms and are considered to be cosmopolitan organisms with wide niche tolerances. The dominant species in Caddo indicate the lake to be a eutrophic environment. Hartung (1983) also found Caddo to be in a eutrophic state based on physicochemical parameters.

The community was found to be very diverse, partly due to a highly variable physical habitat, but also due to a wide variety and abundance of available food items: phytoplankton, periphyton, plant detritus, aquatic macrophytes, bacteria and other microorganisms.

Grazing effects from planktivorous fish populations and predacious dipteran larvae may be very heavy during the summer season at Caddo. This may be due to selective grazing, by fish, but may also be due to the littoral characteristics of the lake which prevents the zooplankton from vertically migrating and reducing the predator pressure (Wright, et al., 1980). Vertical migration is thought to give the zooplankters some selective advantage by reducing fish predation during the daylight hours. Therefore, grazing pressure from fish populations results in a Caddo Lake zooplankton population made up of smaller, "less-preferred" species. The large swamp region and its associated anoxic conditions during the summer, together with the stressful conditions found in the oil producing region may help select for zooplankters with wide niche tolerances. In addition, the shallow basin with its short hydraulic retention time results in rapid changes in water chemistry and rapid changes in water temperature which also select for species with wide niche tolerances.

Summarization of the data shows some possible effects from offshore oil production on the zooplankton community. Chloride values were found to be significantly (95% Confidence Level) higher in the oil producing region (Hartung, 1983) and the off shore oil wells in this region do accidentally spill brine water and crude oil into the lake (Robert E. Abbott, Coordinator Environmental Affairs, Cononco Inc., Houston, Texas. personal communication). Salt water from offshore oil rigs may be inhibiting the rotifer population. Hutchinson (1967), Pennak (1978) and Ruttner-Kolisko (1974) state that the rotifer community is generally inhibited by elevated chloride levels. A more indirect effect from offshore oil production may be the large numbers of predacious dipteran larvae which are characteristic of Caddo's oil producing region. Ransom and Dorris (1972) found that species diversity (d) decreased however, Chaoborus numbers increased as conductivity increased in Keystone Reservoir, Oklahoma. The increased conductivity values were caused by high concentrations of chlorides. The large numbers of Chaoborus larvae in the oil producing region at Caddo may be due to the absence of other benthic organisms which are incapable of tolerating the conditions found in this region. Furthermore, Chaoborus may be suppressing the planktonic crustacean populations by overgrazing. Hartung (1983) reported relatively high concentrations of crude oil in the bottom sediments at stations 8 and 9. The benthic community there is dominated by oligochaetes and chironomids which consume organics in the bottom muds, and those organisms in turn are fed upon by the dominant member of the zooplankton community, Chaoborus. There is a possibility that the biological concentration of some metals or organic compounds in the crude oils or brine could occur in fish species that feed on Chaoborus.

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APPENDIX I. Zooplankton density values (org/l) during the month of October, 1981.

October, 1981

	STATIONS								
TAXA	1	2	3	4	5	6	7	8	9
Phylum Arthropoda									
Class Crustacea									
Subclass Branchiopoda									
Order Cladocera									
Acropterus harpae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bosmina longirostris	.02	.16	.30	1.8	.78	.10	.22	.03	.03
Bosminopsis detersei	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Camptocercus macrurus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ceriodaphnia lacustris	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chydorus sphaericus	0.0	.03	.03	84.	2.0	.18	.09	.03	.04
Daphnia longispina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Daphnia pulex	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eurycercus lamellatus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Illyocryptus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Leydigia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Macrothrix	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pleuroxus	0.0	.01	.01	0.0	0.0	0.0	0.0	0.0	0.0

APPENDIX I. (Cont.)

Sida crystilina	0.0	0.0	0.0	.60	.06	0.0	0.0	0.0	0.0
Simocephalus serrulata	.01	.04	.04	10.	.39	0.0	.01	0.0	0.0
Phylum Rotatoria									
Asplanchna	0.0	0.0	.91	0.0	.06	0.0	.03	0.0	.01
Brachionus angularis	0.0	.10	.10	.30	.36	.37	2.5	0.0	.56
Brachionus calyciflorus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Conachiloides	0.0	.33	.33	.60	.09	.15	.06	.65	.04
Filinia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kellicottia	.02	.10	.10	0.0	.09	0.0	0.0	0.0	0.0
Keratella cochlearis	.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lecane	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0
Notommata	.01	0.0	0.0	3.6	.03	0.0	0.0	.01	0.0
Philodina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Platyias puatulus	0.0	0.0	0.0	12.	.06	0.0	0.0	.03	.03
Platyias quadracornis	.01	.01	.01	6.1	0.0	0.0	0.0	0.0	.01
Pleosoma	0.0	0.0	0.0	2.4	.09	0.0	0.0	0.0	0.0
Polyarthra	.01	.01	.01	.24	0.0	0.0	0.0	0.0	.03
Pompholyx	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rotaria	0.0	.01	.01	0.0	0.0	0.0	0.0	0.0	0.0
Scaridium longicaudum	0.0	0.0	0.0	.60	0.0	0.0	0.0	0.0	0.0
Syncheata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Testudinella	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tricocerca	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

APPENDIX I. (Cont.)

Trochosphaera solstitialis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subclass Copepods									
Order Eucopoda									
Cyclops bicuspidatus	0.0	0.0	0.0	4.2	0.0	.02	0.0	0.0	.01
Diaptomus siciloides	0.0	0.0	0.0	0.0	.06	0.0	.04	0.0	.02
Ergasilis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eucyclops	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Limnocalanus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mesocyclops edax	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(immature) copepods	.12	.30	12.	39.	25.	4.1	14.	8.2	1.8
Total	1.9	1.0	33.	168	29.	5.0	17.	9.0	2.6

APPENDIX II. Zooplankton density values (org/l) during the month of November, 1981.

November, 1981	STATIONS								
TAXA	1	2	3	4	5	6	7	8	9
Phylum Arthropoda									
Class Crustacea									
Subclass Branchiopoda									
Order Cladocera									
Acropterus harpae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bosmina longirostris	.37	.21	.24	0.0	.06	.03	0.0	0.0	0.0
Bosminopsis detersei	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Camptocercus macrurus	0.0	0.0	0.0	0.0	.01	0.0	0.0	.01	0.0
Ceriodaphnia lacustris	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chydorus sphaericus	.01	.12	1.6	3.1	2.5	.06	.04	0.0	0.0
Daphnia longispina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Daphnia pulex	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eurycercus lamellatus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Illyocryptus	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0
Leydigia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Macrothrix	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pleuroxus	0.0	.03	0.0	0.0	.01	0.0	0.0	0.0	0.0

APPENDIX II. (Cont.)

Sida crystilina	0.0	0.0	0.0	8.7	.10	.01	0.0	0.0	0.0
Simocephalus serrulata	.01	0.0	.12	12.	.04	0.0	0.0	0.0	0.0
Phylum Rotatoria									
Asplanchna	0.0	.06	0.0	2.0	.09	.01	.60	0.0	.01
Brachionus angularis	0.0	.06	0.0	.51	.30	.01	0.0	.21	.03
Brachionus calyciflorus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Conachiloides	0.0	0.0	0.0	0.0	0.0	.36	.53	0.0	0.0
Filinia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kellicottia	0.0	.12	0.0	0.0	0.0	.01	0.0	0.0	0.0
Keratella cochlearis	0.0	.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lecane	0.0	.03	0.0	0.0	0.0	0.0	0.0	0.0	.01
Notommata	0.0	0.0	.12	0.0	.03	0.0	0.0	0.0	0.0
Philodina	0.0	0.0	0.0	4.1	0.0	0.0	0.0	0.0	0.0
Platyias puatulus	0.0	.09	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Platyias quadracornis	0.0	0.0	0.0	0.0	.04	0.0	.01	0.0	0.0
Plecsoma	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Polyarthra	.01	.06	0.0	0.0	0.0	0.0	0.0	0.0	.01
Pompholyx	0.0	.03	0.0	0.0	0.0	0.0	0.0	0.0	.07
Rotaria	0.0	.09	0.0	.51	.03	0.0	0.0	0.0	0.0
Scaridium longicaudum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Syncheata	0.0	.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Testudinella	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tricocerca	0.0	.06	0.0	0.0	0.0	.06	0.0	0.0	0.0

APPENDIX II. (Cont.)

Trochosphaera solstitialis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subclass Copepods									
Order Eucopoda									
Cyclops bicuspidatus	0.0	0.0	.12	.15	.04	0.0	0.0	0.0	0.0
Diaptomus siciloides	0.0	.03	0.0	.51	.01	0.0	.01	.01	.01
Ergasilis	0.0	0.0	0.0	0.0	.03	0.0	0.0	0.0	.03
Eucyclops	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Limnocalanus	0.0	0.0	0.0	1.0	.12	0.0	0.0	0.0	0.0
Mesocyclops edax	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(immature) copepods	1.2	6.5	13.	11.	14.	2.1	3.3	4.0	1.0
Total	1.6	7.5	16.	46.	17.	2.7	4.5	4.2	1.2

APPENDIX III. Zooplankton density values (org/l) during the month of December, 1981.

December, 1981

TAXA	1	2	3	4	5	6	7	8	9
	STATIONS								
Phylum Arthropoda									
Class Crustacea									
Subclass Branchiopoda									
Order Cladocera									
Acropterus harpae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.01
Bosmina longirostris	0.0	.03	.09	.15	0.0	0.0	0.0	0.0	0.0
Bosminopsis detersei	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Camptocercus macrurus	0.0	0.0	0.0	0.0	.01	0.0	0.0	.01	0.0
Ceriodaphnia lacustris	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chydorus sphaericus	0.0	.03	.42	0.0	0.0	.03	0.0	.01	0.0
Daphnia longispina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Daphnia pulex	0.0	0.0	.03	0.0	0.0	0.0	0.0	0.0	0.0
Eurycercus lamellatus	.04	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Illyocryptus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Leydigia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Macrothrix	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pleuroxus	0.0	0.0	.09	0.0	0.0	0.0	0.0	0.0	0.0

APPENDIX III. (Cont.)

Sida crystilina	0.0	0.0	0.0	.03	0.0	0.0	0.0	0.0	0.0
Simocephalus serrulata	0.0	0.0	0.0	0.0	.01	0.0	.07	.01	0.0
Phylum Rotatoria									
Asplanchna	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Brachionus angularis	0.0	0.0	0.0	0.0	0.0	0.0	.04	0.0	0.0
Brachionus calyciflorus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Conachiloides	0.0	0.0	.03	0.0	0.0	0.0	0.0	0.0	0.0
Filinia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kellicottia	0.0	0.0	0.0	0.0	0.0	.01	.01	0.0	0.0
Keratella cochlearis	0.0	0.0	.03	.03	0.0	0.0	.01	.03	0.0
Lecane	0.0	0.0	.03	0.0	0.0	0.0	0.0	0.0	0.0
Notommata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Philodina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Platyias puatulus	0.0	0.0	.03	0.0	0.0	0.0	0.0	0.0	0.0
Platyias quadracornis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pleosoma	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Polyarthra	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pompholyx	0.0	.03	0.0	0.0	0.0	0.0	.03	0.0	0.0
Rotaria	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Scaridium longicaudum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Syncheata	0.0	0.0	0.0	0.0	0.0	0.0	.01	0.0	0.0
Testudinella	0.0	.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tricocerca	0.0	0.0	.03	0.0	0.0	0.0	0.0	0.0	0.0

APPENDIX III. (Cont.)

Trochosphaera solstitialis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subclass Copepods									
Order Eucopoda									
Cyclops bicuspidatus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diaptomus siciloides	0.0	0.0	0.0	0.0	0.0	00	0.0	0.0	0.0
Ergasilis	0.0	0.0	0.0	0.0	.03	0.0	0.0	0.0	0.0
Eucyclops	0.0	0.0	0.0	0.0	.01	0.0	0.0	0.0	.01
Limnocalanus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.01	0.0
Mesocyclops edax	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(immature) copepods	.18	0.0	2.7	0.0	.43	0.0	0.0	.77	.46
Total	.24	.09	3.5	.21	.46	.03	.15	.86	.50

APPENDIX IV. Zooplankton density values (org/l) during the month of January, 1982.

January, 1982

TAXA	STATIONS 1	2	3	4	5	6	7	8	9
Phylum Arthropoda									
Class Crustacea									
Subclass Branchiopoda									
Order Cladocera									
Acropterus harpae	0.0	0.0	.06	0.0	0.0	0.0	0.0	0.0	0.0
Bosmina longirostris	0.0	0.0	.03	.60	.09	.06	.03	0.0	0.0
Bosminopsis detersei	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Camptocercus macrurus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ceriodaphnia lacustris	0.0	.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chydorus sphaericus	.01	.27	3.9	.30	.09	.03	.01	0.0	.03
Daphnia longispina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Daphnia pulex	0.0	0.0	.03	0.0	0.0	0.0	0.0	0.0	0.0
Eurycercus lamellatus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Illyocryptus	0.0	0.0	.21	.03	0.0	0.0	0.0	0.0	0.0
Leydigia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Macrothrix	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pleuroxus	0.0	.15	.06	.03	0.0	.01	.01	0.0	0.0

APPENDIX IV. (Cont.)

Sida crystilina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Simocephalus serrulata	0.0	.12	0.0	.03	0.0	0.0	0.0	0.0	0.0
Phylum Rotatoria									
Asplanchna	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Brachionus angularis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Brachionus calyciflorus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Conachiloides	0.0	0.0	.03	0.0	0.0	0.0	0.0	0.0	0.0
Filinia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kellicottia	0.0	0.0	0.0	.03	.03	0.0	.65	0.0	0.0
Keratella cochlearis	0.0	0.0	0.0	.03	0.0	.07	.45	0.0	0.0
Lecane	0.0	.03	.03	0.0	0.0	0.0	0.0	0.0	0.0
Notommata	0.0	0.0	.06	.06	.03	0.0	0.0	0.0	0.0
Philodina	0.0	.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Platyias puatulus	0.0	.06	.03	0.0	0.0	.03	0.0	0.0	0.0
Platyias quadracornis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pleosoma	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Polyarthra	0.0	.03	0.0	0.0	0.0	0.0	.06	0.0	0.0
Pompholyx	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rotaria	0.0	0.0	.03	0.0	0.0	0.0	0.0	0.0	0.0
Scaridium longicaudum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Syncheata	.02	0.0	0.0	0.0	.21	0.0	.01	.03	0.0
Testudinella	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tricocerca	0.0	.03	.03	.03	.03	.03	.04	0.0	0.0

APPENDIX IV. (Cont.)

Trochosphaera solstitialis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subclass Copepods									
Order Eucopoda									
Cyclops bicuspidatus	0.0	.09	.03	.09	0.0	0.0	0.0	0.0	0.0
Diaptomus siciloides	0.0	.03	.03	0.0	0.0	.03	.02	0.0	0.0
Ergasilis	0.0	.15	.12	0.0	0.0	0.0	0.0	0.0	0.0
Eucyclops	0.0	0.0	0.0	.03	0.0	0.0	0.0	0.0	.06
Limnocalanus	0.0	0.0	.21	0.0	.06	0.0	0.0	0.0	0.0
Mesocyclops edax	0.0	0.0	.21	0.0	.06	0.0	0.0	0.0	0.0
(immature) copepods	0.0	8.9	4.1	4.8	.84	5.1	3.6	0.0	.84
Total	.03	10.	9.0	6.1	1.3	5.3	4.2	.07	.93

APPENDIX V. Zooplankton density values (org/l) during the month of February, 1982

February. 1982

TAXA	STATIONS 1	2	3	4	5	6	7	8	9
Phylum Arthropoda									
Class Crustacea									
Subclass Branchiopoda									
Order Cladocera									
Acropterus harpae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.06	0.0
Bosmina longirostris	.01	.03	.12	.03	.03	.01	.22	0.0	0.0
Bosminopsis detersei	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Camptocercus macrurus	0.0	0.0	.03	0.0	0.0	0.0	0.0	0.0	0.0
Ceriodaphnia lacustris	0.0	0.0	0.0	0.0	0.0	0.0	.01	0.0	0.0
Chydorus sphaericus	.01	.19	3.1	.15	.12	.04	.15	0.0	.01
Daphnia longispina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Daphnia pulex	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eurycercus lamellatus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.01
Illyocryptus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Leydigia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.01
Macrothrix	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pleuroxus	.01	0.0	.09	.03	0.0	0.0	0.0	0.0	.01

APPENDIX V. (Cont.)

Sida crystilina	0.0	0.0	0.0	0.0	0.0	.01	0.0	0.0	0.0
Simocephalus serrulata	0.0	0.0	.12	.03	.03	.01	0.0	0.0	0.0
Phylum Rotatoria									
Asplanchna	0.0	0.0	0.0	0.0	.03	0.0	0.0	0.0	0.0
Brachionus angularis	0.0	0.0	0.0	0.0	0.0	0.0	.01	0.0	0.0
Brachionus calyciflorus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Conachiloides	0.0	0.0	.03	0.0	0.0	0.0	0.0	0.0	0.0
Filinia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kellicottia	.01	.01	0.0	.03	0.0	.03	.06	.03	0.0
Keratella cochlearis	.48	1.4	.06	.36	1.4	.42	.13	.04	.01
Lecane	0.0	0.0	0.0	0.0	0.0	.01	0.0	0.0	0.0
Notommata	0.0	0.0	.06	0.0	0.0	.01	0.0	0.0	.01
Philodina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Platyias puatulus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Platyias quadracornis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pleosoma	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Polyarthra	0.0	0.0	0.0	.03	0.0	0.0	0.0	0.0	0.0
Pompholyx	0.0	.01	0.0	0.0	0.0	.06	0.0	0.0	0.0
Rotaria	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Scaridium longicaudum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Syncheata	.02	0.0	0.0	.03	.03	.06	0.0	0.0	0.0
Testudinella	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tricocerca	0.0	.04	0.0	.03	0.0	.01	.01	0.0	0.0

APPENDIX V. (Cont.)

Trochosphaera solstitialis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subclass Copepods									
Order Eucopoda									
Cyclops bicuspidatus	0.0	0.0	.06	.03	0.0	0.0	0.0	0.0	0.0
Diaptomus siciloides	0.0p	0.0	.03	0.0	0.0	0.0	.04	0.0	.01
Ergasilis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eucyclops	0.0	0.0	0.0	0.0	0.0	0.0	.01	0.0	0.0
Limnocalanus	0.0	0.0	.06	0.0	0.0	0.0	.01	0.0	0.0
Mesocyclops edax	0.0	0.0	0.0	.09	0.0	0.0	.03	0.0	0.0
(immature) copepods	0.0	.81	0.0	4.3	1.4	.89	2.4	.71	0.0
Total	.54	2.5	3.7	5.1	3.1	1.5	3.0	.81	.12

APPENDIX V. (Cont.)

Sida crystilina	0.0	0.0	0.0	0.0	0.0	.01	0.0	0.0	0.0
Simocephalus serrulata	0.0	0.0	.12	.03	.03	.01	0.0	0.0	0.0
Phylum Rotatoria									
Asplanchna	0.0	0.0	0.0	0.0	.03	0.0	0.0	0.0	0.0
Brachionus angularis	0.0	0.0	0.0	0.0	0.0	0.0	.01	0.0	0.0
Brachionus calyciflorus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Conachiloides	0.0	0.0	.03	0.0	0.0	0.0	0.0	0.0	0.0
Filinia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kellicottia	.01	.01	0.0	.03	0.0	.03	.06	.03	0.0
Keratella cochlearis	.48	1.4	.06	.36	1.4	.42	.13	.04	.01
Lecane	0.0	0.0	0.0	0.0	0.0	.01	0.0	0.0	0.0
Notommata	0.0	0.0	.06	0.0	0.0	.01	0.0	0.0	.01
Philodina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Platyias puatulus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Platyias quadracornis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pleosoma	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Polyarthra	0.0	0.0	0.0	.03	0.0	0.0	0.0	0.0	0.0
Pompholyx	0.0	.01	0.0	0.0	0.0	.06	0.0	0.0	0.0
Rotaria	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Scaridium longicaudum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Syncheata	.02	0.0	0.0	.03	.03	.06	0.0	0.0	0.0
Testudinella	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tricocerca	0.0	.04	0.0	.03	0.0	.01	.01	0.0	0.0

APPENDIX VI. Zooplankton density values (org/l) during the month of March, 1982.

March, 1982

TAXA	STATIONS 1	2	3	4	5	6	7	8	9
Phylum Arthropoda									
Class Crustacea									
Subclass Branchiopoda									
Order Cladocera									
Acropterus harpae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.12	0.0
Bosmina longirostris	.01	0.0	0.0	.12	0.0	.04	.33	0.0	0.0
Bosminopsis detersei	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Camptocercus macrurus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ceriodaphnia lacustris	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chydorus sphaericus	0.0	.07	29.	.15	.03	.03	.07	.07	.06
Daphnia longispina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Daphnia pulex	.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eurycercus lamellatus	0.0	0.0	1.3	0.0	.03	0.0	0.0	0.0	0.0
Illyocryptus	0.0	0.0	.27	0.0	0.0	0.0	0.0	0.0	0.0
Leydigia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.01
Macrothrix	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pleuroxus	.01	.01	2.8	.12	0.0	.01	.01	0.0	.01

APPENDIX VI. (Cont.)

Sida crystilina	0.0	0.0	0.0	0.0	0.0	.01	0.0	0.0	0.0
Simocephalus serrulata	0.0	0.0	.27	0.0	0.0	0.0	0.0	0.0	0.0
Phylum Rotatoria									
Asplanchna	.01	0.0	0.0	0.0	0.0	.04	.12	0.0	0.0
Brachionus angularis	.01	.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Brachionus calyciflorus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Conachiloides	0.0	0.0	0.0	.09	0.0	.01	.06	0.0	0.0
Filinia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kellicottia	.01	.04	0.0	.57	0.0	.07	1.3	0.0	0.0
Keratella cochlearis	.12	1.1	2.1	0.0	0.0	.69	4.3	.01	.01
Lecane	0.0	0.0	.51	0.0	0.0	0.0	0.0	.01	0.0
Notommata	.01	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0
Philodina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Platyias puatulus	0.0	.04	.06	0.0	0.0	0.0	0.0	0.0	0.0
Platyias quadracornis	0.0	0.0	.21	0.0	0.0	0.0	0.0	0.0	.01
Pleosoma	0.0	0.0	0.0	0.0	0.0	0.0	.01	0.0	0.0
Polyarthra	.01	0.0	0.0	0.0	0.0	0.0	.01	0.0	0.0
Pompholyx	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.01	0.0
Rotaria	0.0	0.0	.39	0.0	0.0	0.0	0.0	0.0	0.0
Scaridium longicaudum	0.0	.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Syncheata	0.0	0.0	0.0	0.0	0.0	.28	.27	0.0	0.0
Testudinella	0.0	.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tricocerca	0.0	0.0	0.0	.09	0.0	0.0	0.0	0.0	.01

APPENDIX VI. (Cont.)

Trochosphaera solstitialis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phylum Athropoda									
Class Crustacea									
Subclass Copepods									
Order Eucopoda									
Cyclops bicuspidatus	.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diaptomus siciloides	0.0	0.0	0.0	0.0	0.0	0.0	.03	0.0	0.0
Ergasilis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eucyclops	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Limnocalanus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mesocyclops edax	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(immature) copepods	1.5	.71	4.6	1.6	0.0	5.7	6.8	2.8	.57
Total	1.7	2.0	43.	2.3	.06	6.8	12.	3.1	.71

APPENDIX VII. Zooplankton density values (org/l) during the month of April, 1982.

April, 1982

TAXA	1	2	3	4	5	6	7	8	9
				STATIONS					
Phylum Arthropoda									
Class Crustacea									
Subclass Branchiopoda									
Order Cladocera									
Acropterus harpae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bosmina longirostris	.01	.24	0.0	0.0	0.0	.42	.09	.04	.01
Bosminopsis detersei	0.0	0.0	.03	.06	0.0	0.0	0.0	0.0	0.0
Camptocercus macrurus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ceriodaphnia lacustris	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.01
Chydorus sphaericus	.43	.09	.06	.30	0.0	.07	.03	.03	.02
Daphnia longispina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Daphnia pulex	.01	.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eurycercus lamellatus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Illyocryptus	0.0	0.0	.24	0.0	0.0	0.0	0.0	0.0	0.0
Leydigia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Macrothrix	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pleuroxus	.01	0.0	0.0	.09	0.0	0.0	0.0	.01	0.0

APPENDIX VII. (Cont.)

Sida crystilina	0.0	0.0	0.0	.03	0.0	.01	0.0	0.0	0.0
Simocephalus serrulata	.01	0.0	0.0	0.0	0.0	.01	0.0	.03	0.0
Phylum Rotatoria									
Asplanchna	0.0	.03	0.0	0.0	0.0	.01	.03	.01	0.0
Brachionus angularis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Brachionus calyciflorus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Conachiloides	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Filinia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kellicottia	0.0	0.0	0.0	.03	0.0	0.0	0.0	0.0	0.0
Keratella cochlearis	.01	.03	0.0	.09	0.0	.01	0.0	0.0	0.0
Lecane	.01	0.0	.03	.03	0.0	.01	0.0	.01	0.0
Notommata	0.0	0.0	.03	0.0	0.0	0.0	0.0	0.0	0.0
Philodina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Platyias puatulus	0.0	0.0	0.0	.03	0.0	0.0	0.0	0.0	0.0
Platyias quadracornis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pleosoma	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Polyarthra	0.0	0.0	0.0	0.0	0.0	.03	0.0	0.0	0.0
Pompholyx	.01	0.0	0.0	0.0	0.0	0.0	.03	0.0	0.0
Rotaria	0.0	0.0	.03	.03	0.0	0.0	.01	0.0	0.0
Scaridium longicaudum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Syncheata	0.0	.03	0.0	0.0	0.0	.01	0.0	0.0	0.0
Testudinella	0.0	.03	.03	0.0	0.0	.01	0.0	0.0	0.0
Tricocerca	.01	.03	0.0	0.0	0.0	.01	0.0	0.0	0.0

APPENDIX VII. (Cont.)

Trochosphaera solstitialis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phylum Athropoda									
Class Crustacea									
Subclass Copepods									
Order Eucopoda									
Cyclops bicuspidatus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diaptomus siciloides	.01	.03	.03	0.0	0.0	0.0	0.0	0.0	0.0
Ergasilis	.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eucyclops	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Limnocalanus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mesocyclops edax	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(immature) copepods	.52	1.8	3.4	0.0	0.0	.81	1.1	0.0	1.5
Total	1.0	2.3	3.9	.66	0.0	1.4	1.3	.15	1.6

APPENDIX VII. (Cont.)

Sida crystilina	0.0	0.0	0.0	.03	0.0	.01	0.0	0.0	0.0
Simocephalus serrulata	.01	0.0	0.0	0.0	0.0	.01	0.0	.03	0.0
Phylum Rotatoria									
Asplanchna	0.0	.03	0.0	0.0	0.0	.01	.03	.01	0.0
Brachionus angularis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Brachionus calyciflorus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Conachiloides	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Filinia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kellicottia	0.0	0.0	0.0	.03	0.0	0.0	0.0	0.0	0.0
Keratella cochlearis	.01	.03	0.0	.09	0.0	.01	0.0	0.0	0.0
Lecane	.01	0.0	.03	.03	0.0	.01	0.0	.01	0.0
Notommata	0.0	0.0	.03	0.0	0.0	0.0	0.0	0.0	0.0
Philodina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Platyias puatulus	0.0	0.0	0.0	.03	0.0	0.0	0.0	0.0	0.0
Platyias quadracornis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pleosoma	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Polyarthra	0.0	0.0	0.0	0.0	0.0	.03	0.0	0.0	0.0
Pompholyx	.01	0.0	0.0	0.0	0.0	0.0	.03	0.0	0.0
Rotaria	0.0	0.0	.03	.03	0.0	0.0	.01	0.0	0.0
Scaridium longicaudum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Syncheata	0.0	.03	0.0	0.0	0.0	.01	0.0	0.0	0.0
Testudinella	0.0	.03	.03	0.0	0.0	.01	0.0	0.0	0.0
Tricocerca	.01	.03	0.0	0.0	0.0	.01	0.0	0.0	0.0

APPENDIX VIII. Zooplankton density values (mg/l) during the month of May, 1982.

May, 1982

TAXA	STATIONS 1	2	3	4	5	6	7	8	9
Phylum Arthropoda									
Class Crustacea									
Subclass Branchiopoda									
Order Cladocera									
Acropterus harpae	0.0	.33	.66	0.0	0.0	0.0	0.0	0.0	0.0
Bosmina longirostris	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bosminopsis detersei	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Camptocercus macrurus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ceriodaphnia lacustris	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chydorus sphaericus	0.0	.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Daphnia longispina	0.0	.15	0.0	.06	0.0	0.0	0.0	0.0	0.0
Daphnia pulex	0.0	0.0	0.0	.03	0.0	0.0	0.0	0.0	0.0
Eurycercus lamellatus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Illyocryptus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Leydigia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Macrothrix	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pleuroxus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

APPENDIX VIII. (Cont.)

Sida crystilina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.01
Simocephalus serrulata	0.0	.03	0.0	0.0	0.0	.06	0.0	.18	.03
Phylum Rotatoria									
Asplanchna	0.0	.03	.27	0.0	0.0	.03	0.0	.04	.03
Brachionus angularis	0.0	0.0	.03	.06	0.0	0.0	0.0	.01	0.0
Brachionus calyciflorus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Conachiloides	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Filinia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kellicottia	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Keratella cochlearis	0.0	0.0	0.0	0.0	0.0	.03	0.0	.03	0.0
Lecane	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Notommata	0.0	.12	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Philodina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Platyias puatulus	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Platyias quadracornis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pleosoma	0.0	0.0	.03	0.0	0.0	0.0	0.0	0.0	0.0
Polyarthra	0.0	0.0	.03	0.0	0.0	0.0	0.0	0.0	0.0
Pompholyx	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rotaria	0.0	0.0	.03	0.0	0.0	.06	0.0	0.0	0.0
Scaridium longicaudum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Syncheata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Testudinella	0.0	.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tricocerca	0.0	0.0	.03	0.0	0.0	0.0	0.0	.04	0.0

APPENDIX VIII. (Cont.)

Trochosphaera solstitialis	0.0	.15	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phylum Athropoda									
Class Crustacea									
Subclass Copepods									
Order Eucopoda									
Cyclops bicuspidatus	0.0	.06	0.0	0.0	0.0	0.0	0.0	.27	0.0
Diaptomus siciloides	0.0	.12	0.0	.06	0.0	0.0	0.0	.10	0.0
Ergasilis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eucyclops	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Limnocalanus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mesocyclops edax	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(immature) copepods	0.0	1.9	1.5	0.0	0.0	2.2	0.0	3.4	1.0
Total	0.0	2.7	2.9	.33	0.0	2.5	0.0	11.5	1.9

APPENDIX VIII. (Cont.)

Trochosphaera solstitialis	0.0	.15	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phylum Athropoda									
Class Crustacea									
Subclass Copepods									
Order Eucopoda									
Cyclops bicuspidatus	0.0	.06	0.0	0.0	0.0	0.0	0.0	.27	0.0
Diaptomus siciloides	0.0	.12	0.0	.06	0.0	0.0	0.0	.10	0.0
Ergasilis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eucyclops	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Limnocalanus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mesocyclops edax	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(immature) copepods	0.0	1.9	1.5	0.0	0.0	2.2	0.0	3.4	1.0
Total	0.0	2.7	2.9	.33	0.0	2.5	0.0	11.5	1.9

APPENDIX IX. Zooplankton density values (org/l) during the month of June, 1982.

June, 1982

TAXA	STATIONS 1	2	3	4	5	6	7	8	9
Phylum Arthropoda									
Class Crustacea									
Subclass Branchiopoda									
Order Cladocera									
Acropterus harpae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bosmina longirostris	0.0	0.0	0.0	.06	.03	0.0	0.0	0.0	0.0
Bosminopsis detersei	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.07	0.0
Camptocercus macrurus	0.0	0.0	.06	0.0	0.0	0.0	0.0	0.0	0.0
Ceriodaphnia lacustris	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chydorus sphaericus	.01	0.0	.03	.03	0.0	0.0	0.0	0.0	0.0
Daphnia longispina	.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Daphnia pulex	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eurycercus lamellatus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Illyocryptus	0.0	.18	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Leydigia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Macrothrix	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pleuroxus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

APPENDIX IX. (Cont.)

Sida crystilina	0.0	0.0	0.0	.06	0.0	0.0	0.0	0.0	0.0
Simocephalus serrulata	0.0	0.0	.03	.06	0.0	0.0	0.0	.01	.03
Phylum Rotatoria									
Asplanchna	0.0	0.0	.09	0.0	0.0	0.0	0.0	.01	0.0
Brachionus angularis	0.0	0.0	0.0	0.0	0.0	0.0	.01	0.0	0.0
Brachionus calyciflorus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Conachiloides	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Filinia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kellicottia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Keratella cochlearis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lecane	0.0	.03	.36	0.0	0.0	0.0	0.0	0.0	0.0
Notommata	0.0	0.0	.69	0.0	0.0	0.0	0.0	0.0	0.0
Philodina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Platyias puatulus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Platyias quadracornis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pleosoma	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Polyarthra	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pompholyx	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rotaria	0.0	0.0	.33	0.0	0.0	0.0	0.0	0.0	0.0
Scaridium longicaudum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Syncheata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Testudinella	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tricocerca	0.0	0.0	.03	0.0	0.0	0.0	0.0	0.0	0.0

APPENDIX IX. (Cont.)

Trochosphaera solstitialis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phylum Athropoda									
Class Crustacea									
Subclass Copepods									
Order Eucopoda									
Cyclops bicuspidatus	0.0	.06	.06	0.0	0.0	0.0	0.0	0.0	0.0
Diaptomus siciloides	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ergasilis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eucyclops	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Limnocalanus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mesocyclops edax	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(immature) copepods	0.0	1.5	1.3	2.3	0.0	.71	0.0	.95	0.0
Total	.02	1.8	3.0	2.5	.03	.71	.01	1.0	.03

APPENDIX X. Zooplankton density values (org/l) during the month of July, 1982.

July, 1982

TAXA	STATIONS 1	2	3	4	5	6	7	8	9
Phylum Arthropoda									
Class Crustacea									
Subclass Branchiopoda									
Order Cladocera									
Acropterus harpae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bosmina longirostris	0.0	0.0	0.0	0.0	.06	0.0	.01	0.0	0.0
Bosminopsis detersei	0.0	0.0	0.0	0.0	.06	0.0	0.0	.01	0.0
Camptocercus macrurus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ceriodaphnia lacustris	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chydorus sphaericus	0.0	.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Daphnia longispina	.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.01
Daphnia pulex	.18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eurycercus lamellatus	0.0	.16	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Illyocryptus	0.0	.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Leydigia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Macrothrix	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pleuroxus	.01	.07	.03	0.0	.06	0.0	0.0	0.0	0.0

APPENDIX X. (Cont.)

Sida crystilina	0.0	.07	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Simocephalus serrulata	.02	.06	0.0	.06	.03	0.0	0.0	0.0	0.0
Phylum Rotatoria									
Asplanchna	0.0	0.0	0.0	0.0	0.0	.03	.01	0.0	0.0
Brachionus angularis	0.0	0.0	0.0	0.0	0.0	.03	0.0	0.0	0.0
Brachionus calyciflorus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Conachiloides	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Filinia	0.0	0.0	.03	0.0	0.0	0.0	0.0	0.0	0.0
Kellicottia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Keratella cochlearis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.01
Lecane	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Notommata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Philodina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.01	0.0
Platyias puatulus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Platyias quadracornis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pleosoma	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Polyarthra	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pompholyx	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rotaria	0.0	0.0	0.0	0.0	0.0	0.0	.03	0.0	0.0
Scaridium longicaudum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Syncheata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Testudinella	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tricocerca	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

APPENDIX X. (Cont.)

Trochosphaera solstitialis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phylum Athropoda									
Class Crustacea									
Subclass Copepods									
Order Eucopoda									
Cyclops bicuspidatus	0.0	.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diaptomus siciloides	0.0	.01	0.0	0.0	0.0	.03	0.0	0.0	0.0
Ergasilis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eucyclops	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Limnocalanus	.05	.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mesocyclops edax	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(immature) copepods	.56	6.0	0.0	0.0	1.5	0.0	0.0	.63	0.0
Total	.84	6.5	.06	.06	1.7	.09	.06	.66	.03

APPENDIX XI. Zooplankton density values (org/l) during the month of August, 1982.

August, 1982

TAXA	STATIONS 1	2	3	4	5	6	7	8	9
Phylum Arthropoda									
Class Crustacea									
Subclass Branchiopoda									
Order Cladocera									
Acropterus harpae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bosmina longirostris	.01	.01	0.0	.06	.06	.03	.01	0.0	0.0
Bosminopsis detersei	.01	0.0	0.0	2.0	.06	0.0	0.0	0.0	.03
Camptocercus macrurus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ceriodaphnia lacustris	.04	0.0	0.0	0.0	.06	0.0	0.0	0.0	0.0
Chydorus sphaericus	0.0	0.0	0.0	.12	.15	.03	0.0	0.0	0.0
Daphnia longispina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Daphnia pulex	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eurycercus lamellatus	0.0	0.0	0.0	0.0	.06	0.0	0.0	0.0	0.0
Illyocryptus	0.0	0.0	0.0	0.0	.15	0.0	0.0	0.0	0.0
Leydigia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Macrothrix	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pleuroxus	0.0	0.0	0.0	.03	0.0	0.0	0.0	0.0	.01

APPENDIX XI. (Cont.)

Sida crystilina	0.0	.01	0.0	.30	.27	0.0	0.0	0.0	0.0
Simocephalus serrulata	.01	.04	0.0	.33	1.2	0.0	0.0	0.0	.04
Phylum Rotatoria									
Asplanchna spp.	.03	.28	.36	.03	0.0	0.0	.04	.10	0.0
Brachionus angularis	0.0	.03	0.0	.18	.06	.03	.78	.03	.07
Brachionus calyciflorus	0.0	.01	0.0	0.0	.06	0.0	0.0	.16	0.0
Conachiloides	0.0	.01	0.0	.06	0.0	0.0	0.0	0.0	0.0
Filinia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kellicottia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Keratella cochlearis	0.0	.01	0.0	.03	0.0	0.0	0.0	0.0	0.0
Lecane	0.0	0.0	0.0	.18	.03	.03	0.0	0.0	.13
Notommata spp.	0.0	0.0	0.0	.06	0.0	0.0	0.0	.03	.03
Philodina	0.0	0.0	0.0	0.0	.03	0.0	0.0	0.0	0.0
Platyias puatulus	0.0	0.0	0.0	1.8	.06	0.0	0.0	0.0	0.0
Platyias quadracornis	0.0	.04	0.0	.06	0.0	0.0	0.0	0.0	0.0
Pleosoma	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Polyarthra	.01	0.0	0.0	0.0	0.0	0.0	0.0	.01	0.0
Pompholyx	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rotaria	0.0	.03	.54	.03	0.0	0.0	0.0	0.0	0.0
Scaridium longicaudum	0.0	0.0	0.0	0.0	.03	0.0	.03	0.0	0.0
Syncheata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Testudinella	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tricocerca	0.0	0.0	0.0	0.0	.06	0.0	0.0	0.0	0.0

APPENDIX XI. (Cont.)

Trochosphaera solstitialis	0.0	0.0	0.0	0.0	.03	0.0	0.0	0.0	0.0
Phylum Athropoda									
Class Crustacea									
Subclass Copepods									
Order Eucopoda									
Cyclops bicuspidatus	0.0	.03	0.0	.06	0.0	0.0	0.0	0.0	0.0
Diaptomus siciloides	0.0	0.0	8.0	0.0	0.0	0.0	0.0	0.0	0.0
Ergasilis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.01	0.0
Eucyclops	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Limnocalanus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mesocyclops edax	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(immature) copepods	2.1	3.1	3.3	11.3	57.	0.0	0.0	1.9	3.2
Total	2.2	3.7	12.	16.	59.	.12	.87	2.3	3.5

APPENDIX XII. Zooplankton density values during the month of September, 1982.

September, 1982

TAXA	STATIONS 1	2	3	4	5	6	7	8	9
Phylum Arthropoda									
Class Crustacea									
Subclass Branchiopoda									
Order Cladocera									
Acropterus harpae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bosmina longirostris	.06	0.0	0.0	.15	0.0	.03	0.0	0.0	.03
Bosminopsis detersei	.12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Camptocercus macrurus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ceriodaphnia lacustris	0.0	0.0	0.0	0.0	.12	0.0	0.0	0.0	0.0
Chydorus sphaericus	0.0	.01	0.0	.54	0.0	0.0	0.0	0.0	0.0
Daphnia longispina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Daphnia pulex	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eurycercus lamellatus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Illyocryptus	.01	0.0	.03	0.0	0.0	.03	0.0	.03	0.0
Leydigia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Macrothrix	0.0	0.0	0.0	.45	.06	0.0	0.0	0.0	0.0
Pleuroxus	0.0	0.0	0.0	.03	0.0	0.0	.03	.03	.06

APPENDIX XII. (Cont.)

Sida crystilina	.29	0.0	0.0	.27	0.0	.87	0.0	0.0	0.0
Simocephalus serrulata	.01	.03	0.0	.12	0.0	0.0	0.0	0.0	.06
Phylum Rotatoria									
Asplanchna	.15	0.0	1.1	0.0	0.0	.21	0.0	.09	.03
Brachionus angularis	.01	0.0	0.0	.06	.03	1.4	2.5	.75	.12
Brachionus calyciflorus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Conachiloides	0.0	0.0	0.0	0.0	0.0	.09	.12	.06	.06
Filinia	0.0	0.0	.03	0.0	0.0	0.0	0.0	0.0	0.0
Kellicottia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Keratella cochlearis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lecane	.01	.01	.03	.18	0.0	0.0	.01	0.0	0.0
Notommata	0.0	.11	.18	.03	0.0	0.0	0.0	.03	.03
Philodina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Platyias puatulus	.01	.12	.15	.03	0.0	0.0	.03	0.0	0.0
Platyias quadracornis	.01	.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pleosoma	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Polyarthra	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pompholyx	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rotaria	0.0	0.0	.09	.03	0.0	0.0	0.0	0.0	0.0
Scaridium longicaudum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Syncheata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.03
Testudinella	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.03	0.0
Tricocerca	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

APPENDIX XII. (Cont.)

Trochosphaera solstitialis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Phylum Athropoda

Class Crustacea

Subclass Copepods

Order Eucopoda

Cyclops bicuspidatus	0.0	0.0	0.0	0.0	.12	0.0	0.0	0.0	0.0
Diaptomus siciloides	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ergasilis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eucyclops	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Limnocalanus	0.0	0.0	0.0	0.0	0.0	0.0	.03	0.0	0.0
Mesocyclops edax	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(immature) copepods	6.1	2.5	1.1	6.2	0.0	1.8	17.	5.4	.78
Total	6.8	3.0	2.6	8.3	.21	4.4	20.	6.4	1.2

THE ZOOPLANKTON COMMUNITY OF CADDO LAKE TEXAS AND LOUISIANA,
A LAKE WITH NUMEROUS OFFSHORE OIL WELLS

APPROVED:

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of the Graduate School

THE ZOOPLANKTON COMMUNITY OF CADDO LAKE TEXAS AND LOUISIANA,

A LAKE WITH NUMEROUS OFFSHORE OIL WELLS

by

TIMOTHY E. VENNEMAN, B. S.

Presented to the Faculty of the Graduate School of

Stephen F. Austin State University

In Partial Fulfillment

of the Requirements

For the Degree of

Master of Science

STEPHEN F. AUSTIN STATE UNIVERSITY

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ABSTRACT

A twelve month study of the zooplankton community at Caddo Lake was conducted beginning in October 1981. A total of 42 taxa were found with an annual mean standing crop of 59.0 org/l. The immature copepods (nauplii and copepodids) dominated the zooplankton community with 64.5%, the cladocerans had 27.8%, the rotifers represented 10.2% and the adult copepods had 2.1%. The dominant organisms found in Caddo Lake are ones which have broad niche tolerances and are generally considered to be indicators of eutrophic conditions. The fall was most productive and the summer was the least. Low spring and summer densities may be due to intensive grazing pressure by a large shad population. The open water region was the most productive and the oil producing region was the least. The low cladoceran density in the oil producing region was attributed to a high density of Chaoborus punctipennis and the grazing by planktivorous fish. The low rotifer density in this region may be caused by chlorides from offshore oil wells.

VITA

Timothy E. Venneman was born in Covington, Kentucky on July 27, 1952. After graduating from Campbell County High School in Kentucky, he enlisted in the United States Navy for six years. In 1976 he entered Northern Kentucky University and received a Bachelor of Science degree from Stephen F. Austin State University in 1980. The next semester he entered the Graduate School of Stephen F. Austin State University. While in graduate school he was a research assistant in a project involving a study of the zooplankton community of three reservoirs, and was also employed as a chemical analyst by Bay Chemical Company. He is the Co-Author of an article entitled "The Occurrence of the rotifer Trochosphaera solstitialis in Reelfoot Lake, Tennessee" which was published by the Tennessee Journal of Science. He recveived a Master of Science degree in Biology in August 1984.

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This thesis was typed by Timothy E. Venneman using the TEXT Program and a Honeywell CP-6 Computer System.