Hoyer

RELATIVE ECOLOGICAL VALUE OF COMMON AQUATIC PLANTS

Final Report

submitted to

Bureau of Aquatic Plant Research and Control
Florida Department of Natural Resources
Tallahassee, Florida

submitted by

Harold L. Schramm, Jr.
Mark V. Hoyer
Kurt J. Jirka
Center for Aquatic Weeds
Institute of Food and Agricultural Sciences
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Gainesville, Florida

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INTRODUCTION

Aquatic macrophytes are prominent components of many aquatic ecosystems. These plants can become overabundant. Overabundant macrophytes cause water quality problems, degrade aesthetic value of the resource, and interfere with recreational, navigational, agricultural and flood control uses of the water body. The problem of nuisance-level aquatic macrophytes has been greatly expanded by the introduction of exotic species such as waterhyacinth (*Eichhornia crassipes*), alligator weed (*Alternanthera philoxeroides*), Eurasian watermilfoil (*Myriophyllum spicatum*), and hydrilla (*Hydrilla verticillata*). Not only do exotic macrophytes frequently become overabundant, they often outcompete more desirable native plants.

Technologies are currently available to control aquatic macrophytes (Shireman and Haller 1982). New products and technologies and additional biological information about different macrophyte species will likely improve the aquatic weed manager's ability to control macrophytes. In light of the multiple uses, and especially the increasing recreational value of our finite aquatic resources, aquatic plant managers need information about the types and quantities of aquatic macrophytes necessary to maintain or improve the water quality, fisheries, and biological functions of the aquatic ecosystem.

The role of aquatic macrophytes in lake ecosystems has been considered in numerous studies from the 1880's to the present. These investigations indicate macrophytes exert beneficial and detrimental impacts on the aquatic ecosystem. Findings from recent studies in Florida suggest that quantity (density, biomass) and quality (species, species assemblages, spatial growth form) of macrophytes are important factors that should be considered in assessing the ecological value of aquatic macrophytes. Thorough understanding of the quantities and qualities of macrophytes necessary to maintain balanced, productive and useful aquatic systems will provide information needed for the formulation of ecologically sound aquatic plant management plans.

The purpose of this research was to evaluate the effects of different quantities and qualities of aquatic macrophytes on water quality parameters, phytoplankton, epiphytic algae, zooplankton, benthic macroinvertebrates and fishes.

ACKNOWLEDGMENTS

We gratefully acknowledge the individuals and agencies that provided valuable assistance during this project. Doug Colle, Jeff Doerzbacher, William Haller, Alberto Korgi, Richard Roberts, and David Smith assisted with sample collection and analyses. Mary Rutter and Dan Canfield conducted laboratory analyses of water quality parameters. The St. Johns River Water Management District provided necessary herbicide treatments in Orange Lake. These treatments were coordinated by Porter Lambert and John Layer and conducted by Jim Wilmoth and Ed Davis. Tom Dick, Division of Aquatic Services, Citrus County provided information about aquatic plant management activities in Lake Henderson. The US Army Corps of Engineers, Palatka Office, provided and maintained the aquatic plant biomass sampler used throughout this study. The US Geological Survey, Southwest Florida Water Management District, and St. Johns Water Management District provided hydrologic and precipitation data for the study lakes. Kenneth Portier contributed to the management and statistical analysis of data. Kathleen Perry patiently typed the report.

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AQUATIC MACROPHYTES

Biomass of aquatic macrophytes was measured bimonthly at each station, concomitantly with water quality, periphyton, phytoplankton, zooplankton, and benthic macroinvertebrates, from October 1982-August 1983 (Table 1). Samples were collected with a Corps of Engineers plant biomass sampler. Ten random samples were collected in hydrilla, spatterdock and open water stations; and, because of limited areal extent, five random samples were collected in maidencane stations. Samples collected with the biomass sampler were separated by genus and wet weights were measured. Aerial parts of spatterdock, maidencane and waterhyacinth were removed before weighing. Stem density was measured at emergent plant stations. At spatterdock stations, *Nuphar* stems in 5 random casts of a 3m x 3m frame were counted. At maidencane stations, *Panicum* and *Paspalidium* stems in five random casts of 1m x 1m frame were counted. These data in conjunction with mean weight per stem calculated for *Nuphar* (n=30 stems), *Panicum* (n=150 stems), and *Paspalidium* (n=150 stems) from each lake during the study period provided a second estimate of biomass for spatterdock and maidencane. Plant biomass was measured during all sampling trips except Trip 2 when the biomass sampler was inoperable.

Table 1. Sampling schedule.

		Sampling Trip					
		Fall		Spring			
Lake	Sample Type	1	2	3	4	5	6
Orange	Plant biomass, water quality, periphyton, phytoplankton, zooplankton, and benthic macroinvertebrates	20-23 Oct 83	15-17 Dec 82	2-8 Mar 83	20-25 Apr 83	17-21 Jun 83	9-10 Aug 83
	Electroshocking	18-19 Oct 83	13-14 Dec 82	28 Feb-1 Mar 83	18-19 Apr 83	15-16 Jun 83	11-12 Aug 83
	Blocknet-rotenone	9 Nov-2 Dec 83		14-25 Mar 83			
Henderson	Plant biomass, water quality, periphyton, phytoplankton, zooplankton, and benthic macroinvertebrates	26 Oct-5 Nov 83	4-7 Jan 83	22-25 Feb 83	1-4 May 83	9-12 Jun 83	2-5 Aug 83
	Electroshocking	25 Oct 82	3 Jan 83	21 Feb 83	28 Apr 83	13 Jun 83	1 Aug 83
	Blocknet-rotenone	6-10 Dec 82		28 Mar-1 Apr 83			

WATER QUALITY

Physical, chemical, and biological water quality parameters were measured bimonthly. Water temperature and dissolved oxygen concentrations were measured in situ at 0.1 m, 1.0 and 2.0 m from the surface with an oxygen meter, (YSI, Model 57). Light extinction coefficients were determined with an underwater photometer (Protomatic). Water samples were collected 0.5 m below the surface in acid-cleaned Nalgene bottles taking care not to disturb periphyton communities in macrophyte stations. Samples were kept on ice and returned to the laboratory for analysis. Parameters measured included pH, total alkalinity (mg/liter as $CaCO_3$), calcium and total hardness (mg/liter as $CaCO_3$), specific conductance (umho/cm^2 at 25 C), total nitrogen (mg/m^3), total phosphorus (mg/m^3) and chlorophyll *a* (mg/m^3). Analyses were those of Standard Methods (APHA 1975).

PERIPHYTON

Periphyton biomass was estimated bimonthly at each station using a method modified after Gough and Woelkerling (1976). Approximately 100 g wet weight of each macrophyte present was carefully removed, placed in 500 ml of tap water in a 1-liter widemouth Nalgene bottle, and placed on ice. The portion of macrophyte sampled was from 0.1-0.5 m below the water surface. Periphyton was removed by shaking within seven hours of sampling. Each sample was shaken manually for 30 seconds and the supernatant poured through a 1.00 mm screen. This procedure was repeated three times for each plant sample, adding 500 ml of tap water for each shaking, producing a total of 1500 ml of supernatant. (The efficiency of this methodology is evaluated in Appendix A.). The supernatant was subsampled, filtered on a Gelman Type A-E glass fiber filter and analyzed for chlorophyll *a* according to Standard Methods (APHA 1975). After removal of epiphytic macroinvertebrates wet and dry weights (24 hours at 60 C) of the macrophyte samples were determined. Periphyton biomass was recorded as milligrams of chlorophyll *a* per gram wet weight of host macrophyte for three washes. Annual mean periphyton biomass in each station was estimated by multiplying annual mean plant biomass for each macrophyte species present by the annual mean periphyton biomass (mg chlorophyll *a* /kg wt weight host macrophyte), then pooling over macrophyte species at each station. Annual habitat mean was the mean for the three stations in each habitat.

PHYTOPLANKTON

Bimonthly phytoplankton samples were collected at each station in acid-cleaned Nalgene bottles. Samples were collected 0.5 m from the surface, taking care not to disturb periphyton in macrophyte stations. Samples were preserved in the field with Lugol's iodine solution (2% concentration). In the laboratory, samples were concentrated, as needed, with a centrifuge and placed in a Palmer cell. Phytoplankton was identified (usually to genus) and enumerated using a phase contrast microscope (Nikon) at 400X. For each sample, 20 fields were viewed or a sufficient number of fields viewed to count 100 cells, whichever was greater. Identification followed Whitford and Schumacher (1973). Cell counts were recorded as cells per liter of lake water.

ZOOPLANKTON

Bimonthly zooplankton samples were collected with an 80 um mesh Wisconsin net with a mouth diameter of 12 cm. Five replicate 1.5 m vertical tows were made at each station on each date. These samples were combined in the field and preserved with 5% formalin. In the laboratory, 3 separate 1 ml subsamples were taken with a large bore pipet (3 mm) and placed in a Sedgwick-Rafter cell for identification (usually to genera) and enumeration. A phase contrast microscope (Nikon) at 100X was used. Identification was according to Pennak (1978) and Edmondson (1959). Zooplankton numbers were recorded as individuals/liter.

BENTHIC MACROINVERTEBRATES

Two distinct communities of benthic macroinvertebrates were sampled bimonthly: hydrosoil macroinvertebrates and epiphytic macroinvertebrates. In this study, hydrosoil macroinvertebrates are organisms living in and on the bottom sediments. Epiphytic macroinvertebrates are organisms on submersed portions of aquatic macrophytes. Hydrosoil macroinvertebrates were collected from the hydrosoil with five petite ponar grabs (272 cm²/grab) at each station on each date. Samples were combined in the field, washed in a 0.7 mm mesh sieve and preserved in 10% formalin. In the laboratory, organisms were separated from detritus and preserved in 95% alcohol. Invertebrate numbers and weights were expressed on a bottom surface area (m²) basis.

Epiphytic macroinvertebrates were collected from the plant material used for periphyton sampling commencing in December. After periphyton removal, the plant material was preserved in 10% formalin and epiphytic macroinvertebrates removed prior to weighing the plant material. This will be referred to as the plant sample method. In habitats with emergent vegetation, epiphytic macroinvertebrates were also collected with a 1.2 mm mesh dip net. The net was pushed against the plant stems 1.5 m below the surface and raised to the surface while scraping the plant stems. Sampling was repeated until a minimum of 30 organisms were collected, and the number of sweeps was recorded (range 2-25). This method will be referred to as the sweep method. Hydrosoil and epiphytic macroinvertebrates were enumerated and identified to the lowest practical taxa (usually genera) according to Edmondson (1959), Wiggins (1977) and Pennak (1978) using a dissecting microscope at 60X. Organisms were then dried at 60 C for 24 hours and weighed to the nearest milligram. For the sweep method, abundance was expressed as number of individuals/sweep (density) and mg dry weight/sweep (biomass). For the plant sample method abundance was expressed as number of individuals/kg wet weight host plant (density) and

mg dry weight/kg wet weight host plant (biomass). Estimates of epiphytic macroinvertebrate density/m² (individuals/m²) and biomass/m² (mg dry weight/m²) were derived by multiplying the plant biomass (kg wet weight/m²) of each macrophyte species present by the invertebrate abundance for that species in that habitat for each sampling date. This analysis was performed for sampling trips 3-6 when epiphytic macroinvertebrates and macrophyte biomass were sampled concomittantly. Annual mean abundance/m² was estimated for each station. This estimate was accomplished by multiplying annual mean plant biomass of each macrophyte species in each station by the annual mean abundance/kg wet weight of epiphytic macroinvertebrates on each macrophyte species obtained by the plant sample method, then pooling over macrophyte species in the station. Annual habitat mean was the mean of the three stations in each habitat.

FISH

Sport fish (bluegill[1], redear sunfish, largemouth bass, black crappie, and chain pickerel) were collected with pulsed DC electroshocking at each station bimonthly. Electroshocking was conducted within three days of plant biomass sampling. Electroshocking samples were 15-30 minutes long, depending on the areal extent of the station. Shocking times were recorded to quantify catch per unit effort. Fish collected were kept on ice and returned to the laboratory for analysis. Total length (TL) to the nearest millimeter and weight to the nearest gram were measured. Condition factors (KTL, eq. 1) were calculated for chain pickerel ≥ 240 mm TL, bluegill ≥ 120 mm TL, and largemouth bass ≥ 200 mm TL.

$$\mathrm{KTL} = \frac{\text{weight(g)}}{\text{TL(mm)}} \times 10^5 \qquad \text{Eq. 1}$$

Stomach contents were analyzed for up to 10 fish in each of the following size groups: bluegills 40-149 mm TL and ≥ 150 mm TL; redear sunfish, 40-150 mm TL and ≥ 150 mm TL; largemouth bass, 80-299 mm TL and ≥ 300 mm TL; black crappie, 40-199 mm TL and ≥ 200 mm TL; and chain pickerel 80-299 mm TL and ≥ 300 mm TL.

The entire fish assemblage at each station was assessed with blocknet-rotenone sampling twice during the study period to coincide with low hydrilla and high hydrilla biomass in Orange Lake (Table 1). Blocknet area was 0.08 ha (Shireman et al. 1981). Rotenone (Noxfish, 5% emulsified) was applied uniformly inside each net at 2 mg/liter. Fish were collected for three days, separated by species into 40 mm TL size groups, enumerated and weighed. Data analysis included density (individuals/ha) and biomass (gm/ha) by species and size groups. Biomass of harvestable sport fish and percent harvestable sport fish of total fish biomass were calculated. Harvestable sport fish included chain pickerel and largemouth bass ≥ 320 mm TL, warmouth, bluegill and redear sunfish ≥ 160 mm TL, and black crappie ≥ 200 mm TL.

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[1] Common and scientific names of fish are presented in Appendix B.

Relationships between forage fish and piscivorous fish were evaluated similar to methods of Swingle (1950) and Jenkins and Morais (1976) by comparing the biomass of piscivores (P) to biomass of consummable-size forage fish (F). Forage fish included all species collected. Piscivores included Florida gar, bowfin, chain pickerel, warmouth, largemouth bass, and black crappie. Four F/P ratios were calculated from blocknet-rotenone data as follows:

$$\text{F/P 40} = \frac{\text{gm/ha 0-39 mm TL forage fish}}{\text{gm/ha 40-119 mm TL piscivores}},$$

$$\text{F/P 120} = \frac{\text{gm/ha 0-79 mm TL forage fish}}{\text{gm/ha 120-199 mm TL piscivores}},$$

$$\text{F/P 200} = \frac{\text{gm/ha 0-79 mm TL forage fish}}{\text{gm/ha 200-319 mm TL piscivores}},$$

$$\text{F/P 320} = \frac{\text{gm/ha 0-119 mm TL forage fish}}{\text{gm/ha} \geq \text{320 mm TL piscivores}}.$$

RESULTS AND DISCUSSION

PLANT BIOMASS

Paspalidium was the dominant macrophyte in the Orange Lake maidencane habitat. Biomass sampler and stem count data indicated greater *Paspalidium* biomass in October, June, and August (Tables 2, 3). Although treated with herbicides in August 1982, a large biomass of growing *Hydrilla* remained in October. *Hydrilla* biomass declined during February through August. *Hydrilla* collected during February through August was primarily floating plant parts that drifted into the maidencane islands. A small biomass of *Ceratophyllum* was present in October. *Ceratophyllum* biomass was consistently higher during February through August. A high biomass of *Utricularia* was collected at one station in February. Total plant biomass was highest in October (Table 4) when emergent macrophyte and submergent macrophyte biomass were similar (Figure 1). Submerged plant biomass remained high through February.

In the Orange Lake maidencane-hydrilla habitat biomass sampler data indicated consistently high biomass of *Paspalidium*. Based on stem count data, biomass of *Paspalidium* was higher during October, June and August. *Panicum*, occasionally collected in this habitat, grew in small clumps adjacent to islands of *Paspalidium*. *Hydrilla* was abundant and surface matted in October and present at lower biomass in February-August. A large portion of the *Hydrilla* recorded during February-August was floating plants that drifted into the maidencane islands. *Ceratophyllum* and *Utricularia* were present at low biomass. Total plant biomass was highest in October when emergent and submergent macrophyte biomass were approximately equal. Emergent plant biomass increased sharply in April due to collection of dense *Panicum* at one station.

Nuphar was the dominant emergent macrophyte in the Orange Lake spatterdock habitat. Biomass was higher during

Table 2. Biomass (kg/m^2) of macrophytes collected with Corps of Engineers biomass sampler in Orange Lake, October 1982-August 1983. Numbers in parentheses are number of stations where macrophyte was collected and coefficient of variation (n, C.V.).

Habitat	Macrophyte	Date Oct	 Feb	 Apr	 Jun	 Aug
Maidencane	*Paspalidium*	2.68 (3, 6)	1.68 (3, 85)	2.28 (3, 97)	3.46 (3, 37)	2.90 (3, 37)
	Hydrilla	1.99 (3, 57)	0.59 (3, 31)	0.34 (3, 103)	0.15 (3, 47)	0.20 (3, 130)
	Ceratophyllum	0.01 (2, 50)	0.08 (2, 24)	0.06 (2, 79)	0.06 (2, 6)	0.18 (3, 94)
	Utricularia		1.56 (1, -)			
	Chara			0.01 (1, -)		
	Eichhornia					0.55 (2, 50)
Maidencane-hydrilla	*Paspalidium*	2.79 (3, 55)	3.20 (3, 56)	3.33 (2, 2)	2.91 (3, 73)	2.51 (3, 36)
	Panicum	0.10 (1, -)		1.12 (1, -)		
	Hydrilla	2.49 (3, 50)	0.65 (3, 25)	0.43 (3, 79)	0.38 (3, 78)	0.43 (3, 109)

Table 2. Continued.

Habitat	Macrophyte	Date Oct	 Feb	 Apr	 June	 Aug
Maidencane-hydrilla	<u>Ceratophyllum</u>	0.01 (1, -)	0.01 (2, 50)	0.02 (3, 61)	0.07 (3, 78)	0.04 (3, 127)
	<u>Utricularia</u>		0.01 (2, 86)	0.02 (1, -)	0.04 (1, -)	0.02 (1, -)
	<u>Chara</u>			0.01 (1, -)		
	<u>Eichhornia</u>				0.01 (1, -)	0.12 (2, 15)
Spatterdock	<u>Nuphar</u>	2.10 (3, 16)	3.25 (3, 18)	4.09 (3, 12)	5.62 (3, 13)	2.93 (3, 37)
	<u>Nymphaea</u>				<0.01 (1, -)	
	<u>Ceratophyllum</u>	1.39 (3, 52)	2.06 (3, 86)	1.96 (3, 100)	0.71 (3, 82)	1.59 (3, 148)
	<u>Hydrilla</u>	0.01 (2, 50)	0.01 (2, 117)	0.01 (2, 107)	0.01 (3, 87)	0.01 (2, 29)
	<u>Utricularia</u>		0.03 (3, 61)	0.02 (2, 11)	0.12 (3, 93)	0.26 (3, 141)
	<u>Cabomba</u>	<0.01 (1, -)				

Table 2. Continued.

Habitat	Macrophyte	Date Oct	 Feb	 Apr	 Jun	 Aug
Spatterdock	<u>Egeria</u>				0.01 (1, -)	
	<u>Eleocharis</u>					0.23 (1, -)
	<u>Eichhornia</u>	0.04 (2, 122)	0.08 (2, 90)	0.07 (3, 49)	0.23 (3, 60)	1.28 (3, 107)
	<u>Limnobium</u>			0.01 (1, -)		
	<u>Pistia</u>				0.15 (1, -)	
	<u>Althernanthera</u>				<0.01 (1, -)	0.01 (1, -)
Spatterdock-hydrilla	<u>Nuphar</u>	2.19 (3, 17)	3.20 (3, 42)	4.73 (3, 14)	3.60 (3, 57)	1.71 (3, 65)
	<u>Hydrilla</u>	0.77 (3, 42)	0.61 (3, 72)	0.20 (3, 35)	0.65 (3, 101)	0.30 (3, 93)
	<u>Ceratophyllum</u>	0.24 (3, 66)	0.45 (3, 96)	0.39 (3, 106)	0.43 (3, 121)	0.71 (3, 119)
	<u>Utricularia</u>		0.01 (1, -)	0.01 (3, 44)	0.01 (2, 83)	0.03 (3, 70)
	<u>Najas</u>			<0.01 (1, -)		

Table 2. Continued.

Habitat	Macrophyte	Date Oct	Feb	Apr	Jun	Aug
Spatterdock-hydrilla	*Cabomba*					0.03 (1, -)
	Eichhornia	0.43 (1, -)	0.25 (1, -)	0.70 (3, 99)	0.59 (3, 65)	5.66 (3, 44)
Hydrilla	*Hydrilla*	4.93 (3, 25)	0.93 (3, 37)	0.72 (3, 55)	0.74 (3, 139)	0.48 (3, 92)
	Ceratophyllum	0.02 (2, 123)	0.01 (2, 114)	0.01 (3, 63)	<0.01 (2, 13)	<0.01 (2, 50)
	Utricularia		<0.01 (1, -)			

Table 3. Biomass (kg/m^2) of macrophytes based on stem counts in Orange Lake and Lake Henderson October 1982-August 1983. Numbers in parentheses are coefficient of variation (%).

Lake	Habitat	Macrophyte	Date Oct	Feb	Apr	June	Aug
Orange	Maidencane	Paspalidium	3.08 (46)	.60 (87)	1.04 (45)	3.68 (12)	3.26 (13)
	Maidencane-hydrilla	Paspalidium	3.48 (76)	1.18 (31)	1.26 (39)	3.94 (8)	3.40 (44)
	Spatterdock	Nuphar	2.29 (8)	3.61 (16)	4.37 (5)	5.65 (11)	2.45 (5)
	Spatterdock-hydrilla	Nuphar	1.87 (16)	2.82 (12)	3.74 (6)	4.45 (34)	1.72 (30)
Henderson	Maidencane	Panicum	5.24 (28)	3.23 (20)	7.59 (48)	4.47 (44)	5.08 (38)
	Spatterdock	Nuphar	1.49 (9)	2.40 (18)	3.33 (8)	4.18 (7)	1.59 (17)

Table 4. Total plant biomass (kg·wet·weight/m^2) in different habitats in Orange Lake and Lake Henderson, October 1982-August 1983.

Lake	Habitat	Date Oct	 Feb	 Apr	 Jun	 Aug	Annual Mean
Orange	Maidencane	4.68	2.36	2.69	3.67	3.28	3.34
	Maidencane-hydrilla	5.39	3.87	4.93	3.40	3.12	4.14
	Spatterdock	3.53	5.43	6.17	6.86	6.30	5.66
	Spatterdock-hydrilla	3.62	4.52	6.03	5.28	8.43^a	5.58
	Hydrilla	4.95	0.95	0.73	0.74	0.48	1.57
Henderson	Maidencane	3.21^b	3.14	3.86	4.43	4.31^b	3.79^b
	Spatterdock	1.90	3.24	4.45	3.62	2.91	3.23

[a] Includes 5.63 kg/m^2 *Eichhornia*

[b] Using 2.00 kg/m^2 for *Panicum*

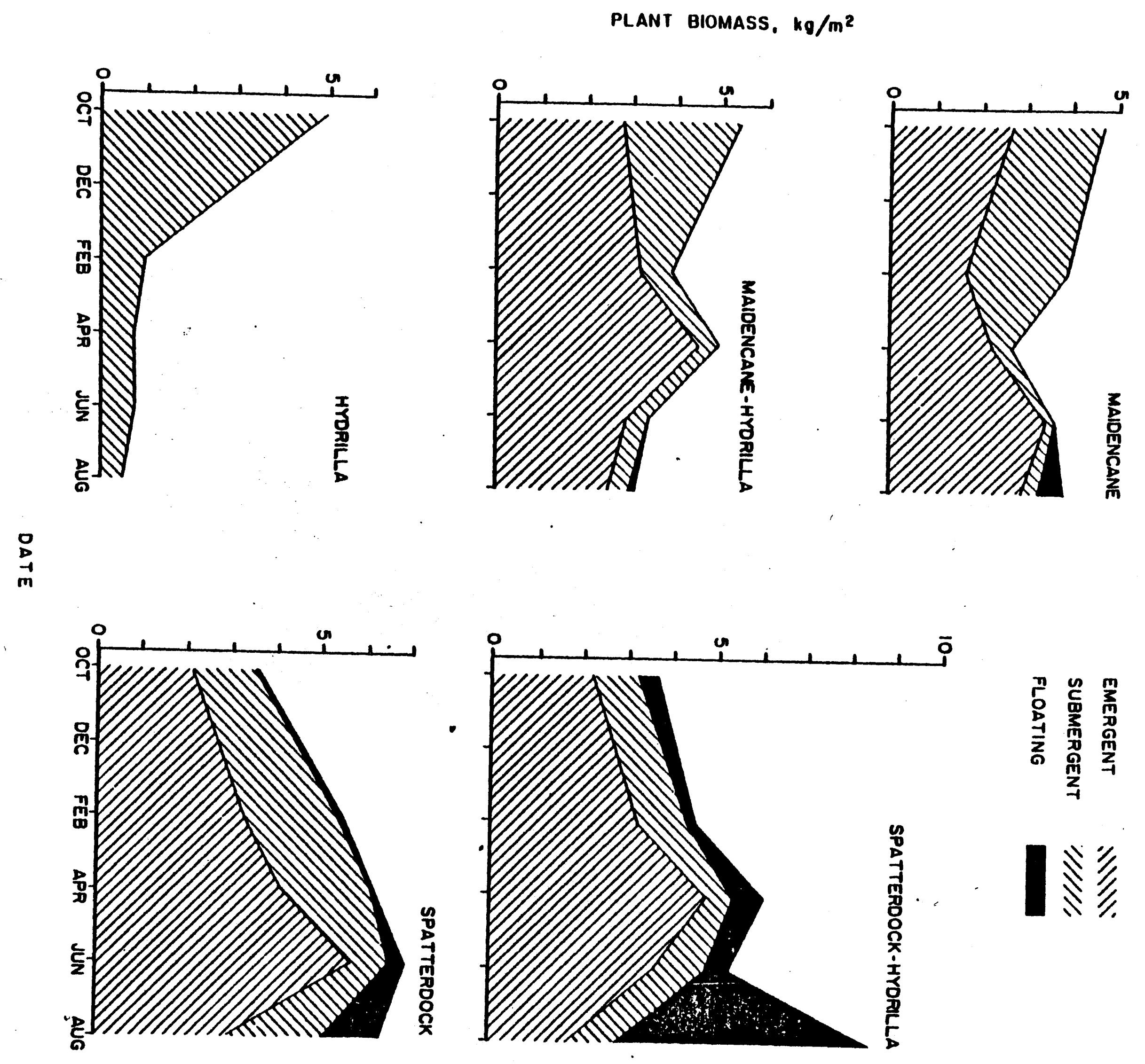

Figure 1. Mean biomass of emergent, submergent, and floating aquatic macrophytes in the maidencane, maidencane-hydrilla, spatterdock, spatterdock-hydrilla, and hydrilla habitats, Orange Lake, October 1982-August 1983.

April and June. *Ceratophyllum* was the dominant submersed macrophyte. Although present at all stations, biomass of *Ceratophyllum* was highly variable among stations. *Eichhornia* increased in abundance throughout the study period; during August dense mats of *Eichhornia* occurred throughout the spatterdock habitat. Four other species of floating plants were present in this diversely vegetated habitat. Total plant biomass peaked in June. At this time, submersed plant biomass was minimal. Total plant biomass remained high in August due to increased biomass of floating macrophytes.

Plant biomass in the Orange Lake spatterdock-hydrilla habitat was primarily *Nuphar*. *Nuphar* biomass was higher in April and June. *Hydrilla* was abundant in October and December 1982 and June 1983. *Hydrilla* was densely surface matted in October and December. These stations consisted of irregular-shaped *Nuphar* islands. *Hydrilla* was the most abundant and most densely matted at the periphery of the islands. *Ceratophyllum* was present at all stations throughout the study; biomass increased during February-August. *Eichhornia* biomass increased sharply in August. Total plant biomass was highest in August due to the high biomass of floating macrophytes. Submersed and emergent plant biomass combined was highest in April. This habitat had the highest biomass of floating plants of all Orange Lake habitats.

Dense, continuous mats of *Hydrilla* occupied much of the historically limnetic area of Orange Lake, including the hydrilla stations, in October 1982. Based on observations during other sampling events, dense surface mats of *Hydrilla* remained through December 1982. *Hydrilla* declined during the winter and continued a slow decline through Summer 1983. The lack of regrowth of *Hydrilla* during June and August 1983 necessitated slight relocation of hydrilla sampling stations; i.e., the sampling stations were moved to areas containing *Hydrilla*. The variability in *Hydrilla* biomass

during June and August relates to the scant amount of *Hydrilla* present during Summer 1983. Also, the biomass of *Hydrilla* in this habitat is not an indication of the total coverage of *Hydrilla* in Orange Lake. Based on visual approximation, *Hydrilla* covered over 90% of the limnetic portion of Orange Lake in Summer 1982. During Summer 1983, *Hydrilla* coverage of the limnetic portion of Orange Lake progressively declined and never exceeded 20% of the limnetic area. Trace amounts of *Ceratophyllum* were typically collected with the *Hydrilla*.

Panicum was the dominant plant in the Lake Henderson maidencane habitat (Table 5). This macrophyte grew in very dense stands in the maidencane habitat. The low biomass recorded in October 1982 and August 1983 resulted from the inability to sample the dense *Panicum* with the biomass sampler. The high stem density in the Lake Henderson maidencane habitat prevented the sampling bucket of the biomass sampler from cutting the stems, and, at times, descending through the *Panicum*. For this reason, total plant biomass (Table 4) was adjusted in October and August. Comparison of biomass estimated by stem count data (Table 3) and stem weight data (Table 6) indicates greater stem density and biomass in the Lake Henderson maidencane habitat than in the Orange Lake maidencane habitat. Stem count data indicate moderate biomass of *Panicum* in October and August and highest biomass in April. Only small amounts of submersed plants were collected in this habitat. *Eichhornia* biomass was relatively high in April-August 1983. *Eichhornia* grew in mats in the *Panicum*. Total plant biomass was highest in August (Table 4). Relatively high biomass of floating plants were present throughout the year, but floating plant biomass was higher during April-August (Figure 2). The emergent vegetation biomass in this habitat was relatively constant compared to the emergent vegetation in the maidencane and maidencane-hydrilla habitats in Orange Lake.

Table 5. Biomass (kg/m^2) of macrophytes collected with Corps of Engineers biomass sampler in Lake Henderson, October 1982-August 1983. Numbers in parentheses are number of stations where macrophyte was collected and coefficient of variation (n, C.V.).

Habitat	Macrophyte	Date Oct	Feb	Apr	Jun	Aug
Maidencane	Panicum	0.03 (3, 1)	2.22 (3, 73)	2.35 (3, 16)	1.69 (3, 78)	0.02 (3, 30)
	Nuphar		0.05 (1, -)			
	Ceratophyllum	0.10 (3, 140)	0.05 (2, 127)	0.01 (2, 50)	0.01 (3, 67)	0.09 (3, 76)
	Hydrilla	0.14 (3, 148)	0.04 (3, 57)	0.02 (2, 2)	0.01 (3, 20)	0.01 (3, 33)
	Chara		0.05 (3, 129)	0.01 (1, -)	0.02 (2, 68)	
	Utricularia	0.01 (1, -)	0.01 (1, -)			0.01 (2, 73)
	Eichhornia	0.90 (3, 54)	0.70 (3, 63)	1.47 (3, 71)	2.68 (3, 15)	2.19 (3, 32)
	Pistia	0.06 (3, 81)	0.01 (2, 50)	0.01 (1, -)		0.01 (1, -)
	Alternanthera				0.01 (1, -)	

Table 5. Continued.

Habitat	Macrophyte	Date Oct	Feb	Apr	Jun	Aug
Spatterdock	Nuphar	1.54 (2, 8)	2.48 (3, 6)	3.15 (3, 7)	3.32 (3, 12)	2.24 (3, 23)
	Panicum	0.34 (2, 137)	0.42 (3, 87)	1.13 (3, 147)	0.13 (2, 77)	<0.01 (1, -)
	Nymphaea		0.07 (1, -)			
	Ceratophyllum	0.01 (2, 20)	0.02 (2, 55)	0.02 (3, 75)	0.02 (3, 95)	0.07 (3, 64)
	Hydrilla	0.01 (2, 5)	0.01 (2, 20)	0.01 (3, 57)	0.02 (3, 30)	0.03 (3, 52)
	Utricularia		0.01 (2, 100)	0.01 (2, 86)	0.01 (1, -)	0.05 (3, 127)
	Cabomba		<0.01 (1, -)	<0.01 (1, -)		0.01 (2, 5)
	Chara		0.01 (1, -)		<0.01 (2, 50)	0.01 (1, -)
	Nitella	<0.01 (1, -)		0.01 (1, -)	0.04 (2, 111)	0.01 (2, 100)
	Najas				<0.01 (1, -)	0.01 (1, -)
	Potamogeton		<0.01 (1, -)		0.01 (1, -)	<0.01 (1, -)

Table 5. Continued.

Habitat	Macrophyte	Date				
		Oct	Feb	Apr	Jun	Aug
Spatterdock	<u>Eleocharis</u>		<0.01 (1, -)		0.01 (1, -)	
	<u>Vallisneria</u>					<0.01 (1, -)
	<u>Eichhornia</u>		0.21 (1, -)	0.12 (2, 30)	0.06 (2, 134)	0.48 (2, 12)
	<u>Pistia</u>		0.01 (1, -)			
Open water	<u>Hydrilla</u>	0.01 (2, 8)	0.01 (2, 80)	0.01 (3, 90)	0.01 (3, 144)	0.01 (3, 100)
	<u>Ceratophyllum</u>	0.01 (1, -)		0.01 (1, -)		0.01 (2, 8)
	<u>Chara</u>	0.01 (1, -)				
	<u>Utricularia</u>		0.01 (1, -)			

Table 6. Mean wet weight of plant stems in Orange Lake and Lake Henderson.

Date	Lake	Plant	Water depth (m)	Number of stems	Mean wet weight per stem (kg)
10 June 83	Henderson	<u>Panicum</u>	2.2	150	0.029
05 Aug 83	Henderson	<u>Panicum</u>	2.2	150	0.027
22 Jun 83	Orange	<u>Paspalidium</u>	2.0	150	0.039
10 Aug 83	Orange	<u>Paspalidium</u>	2.0	150	0.042
10 June 83	Henderson	<u>Nuphar</u>	1.8	27	0.305
05 Aug 83	Henderson	<u>Nuphar</u>	1.8	30	0.142
22 Jun 83	Orange	<u>Nuphar</u>	1.9	30	0.443
10 Aug 83	Orange	<u>Nuphar</u>	1.9	30	0.215

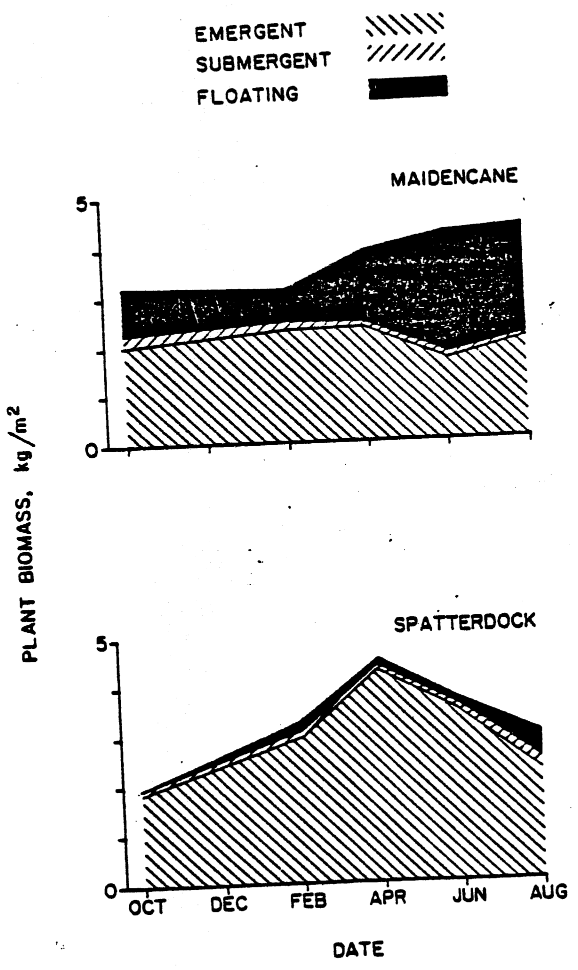

Figure 2. Mean biomass of emergent, submergent, and floating aquatic macrophytes in the maidencane and spatterdock habitats, Lake Henderson, October 1982-August 1983.

Nuphar was the dominant plant in the highly diverse spatterdock habitat in Lake Henderson. Biomass of *Nuphar* was higher in April and June. *Panicum* was intermixed with *Nuphar* in some areas. The *Panicum* in the spatterdock habitat grew sparsely, in contrast to *Panicum* in the maidencane habitat. Low biomass of *Ceratophyllum* and *Hydrilla* were present at most stations on all sampling dates. Total plant biomass in the spatterdock habitat was highest during April. Low biomass of submersed and floating macrophytes were present throughout the study. Temporal trends in total plant biomass in this habitat closely paralleled plant biomass in the spatterdock and spatterdock-hydrilla habitats in Orange Lake if floating plants are excluded.

Sparse amounts of *Hydrilla* were typically collected in the Lake Henderson open water habitat. Although all open water stations were located where dense *Hydrilla* grew in August 1982, it is not known whether the scant amounts of *Hydrilla* collected were growing at these stations or were drifting fragments of *Hydrilla*.

In Orange Lake, the spatterdock and spatterdock-hydrilla habitats contained the greatest plant biomass. These habitats also contained highest plant biomass when biomass of *Eichhornia*, subject to maintenance control operations, was excluded. There was a clear seasonality of plant biomass in both habitat types resulting from increased *Nuphar* biomass in April and June. The greater *Nuphar* biomass during this time period was due to higher weight per stem (Table 6) rather than increased stem density. Temporal variation in total plant biomass in the spatterdock-hydrilla habitat associated with the large reduction of *Hydrilla* in the spring were damped by the magnitude of *Nuphar* biomass and increased biomass of other submergent species.

The hydrilla habitat was characterized by wide seasonal fluctuations in biomass, as described by Haller (1978). In past years, *Hydrilla* biomass in Orange Lake has increased from minimum levels in March-May to maximum levels in October-December. The lack of regrowth in 1983 and continued low biomass likely resulted from herbicide treatment (Sonar) in Winter 1982-1983. No other submersed macrophytes replaced *Hydrilla*. Depth was probably a significant factor affecting colonization by a substitute plant, because the hydrilla stations were in the historically limnetic zone of Orange Lake.

Following the decline of *Hydrilla* the maidencane and maidencane-hydrilla habitats contained moderate and relatively constant plant biomass compared to other habitat types. The apparent discrepancy in seasonal trends of emergent plant biomass between these habitats largely resulted from the collection, due to random sampling, of *Panicum* growing in dense clumps. There was no evidence for other submergent macrophyes replacing *Hydrilla* in these habitats.

Plant biomass in the Lake Henderson spatterdock habitat was lower than Orange Lake spatterdock habitats, due, primarily, to lower biomass of submergent plants and, secondarily, to lower biomass of *Nuphar*.

Plant biomass sampler data indicated lower plant biomass in the Lake Henderson maidencane habitat than in the maidencane habitats in Orange Lake and in the spatterdock habitats in both lakes, despite the presence of moderate biomass of *Eichhornia*. Stem count data, however, indicated the biomass sampler underestimated *Panicum* biomass in Lake Henderson maidencane habitat. Due to observed difficulties with the biomass sampler in the maidencane habitat, we consider the stem count data more valid for this habitat. Therefore, the maidencane habitat contained the highest plant biomass in Lake Henderson and similar biomass to Orange Lake spatterdock habitats.

WATER QUALITY

Measured water quality parameters were similar among habitats in each lake (Table 7,8). Variance component analysis (PROC VARCOMP, SAS Institute 1982) of chlorophyll *a* and plant nutrients indicated large portions of variation accounted for by seasonal fluctuations (Table 9). Analysis of variance (PROC GLM, SAS Institute 1982) of total alkalinity, total nitrogen, total phosphorus, and chlorophyll *a* showed no significant differences among habitat types.

There were differences in water quality parameters between lakes. Total alkalinity, total hardness, pH, and conductivity were higher in Lake Henderson. Total phosphorus (P) was similar between lakes, but total nitrogen (N) was lower in Lake Henderson. Open water N/P ratios were 31.9 and 23.3 in Orange Lake and Lake Henderson, respectively. Chlorophyll *a* levels were lower and less variable in Lake Henderson.

Surface and bottom oxygen levels were quite variable. However, since dissolved oxygen was measured at different times of day, meaningful comparisons of habitats were not possible.

Based on comparison with Likens' (1975) characteristics, Orange Lake is eutrophic. In Lake Henderson, total nitrogen concentrations were within the range for mesotrophic lakes (Likens 1975); however, chlorophyll *a* and total phosphorus concentrations were equivalent to values for eutrophic waters. In disagreement with Attardi (1983), our data supports classifying Lake Henderson as a eutrophic lake.

The significant temporal variations in water quality parameters are consistent with fluctuations in lake level and precipitation (Figures 3, 4). The larger variation in total nitrogen and total phosphorus in Orange Lake than in Lake Henderson may be related to the larger temporal changes

Table 7. Annual mean values for water quality parameters measured in Orange Lake, October 1982-August 1983. Range of values in parentheses.

Parameter	Panicum	Panicum-hydrilla	Nuphar	Nuphar-hydrilla	Hydrilla	Open water
Total Alkalinity (mg/L as $CaCO_3$)	16 (12-19)	17 (13-21)	18 (15-21)	17 (15-20)	16 (13-19)	16 (13-19)
Specific Conductance (µmho/cm^2 at 25°C)	65 (60-73)	65 (58-75)	66 (56-77)	65 (58-74)	65 (59-74)	65 (60-68)
Total Hardness (mg/L as $CaCO_3$)	24 (20-28)	24 (20-28)	25 (21-29)	24 (19-28)	24 (21-28)	24 (21-29)
Total Phosphorus (mg/m^3)	37.5 (16.5-57.6)	36.5 (13.0-55.4)	37.1 (12.8-92.9)	33.6 (10.2-70.4)	38.2 (9.3-56.2)	38.9 (17.2-57.2)
Total Nitrogen (mg/m^3)	1050 (689-2226)	1198 (764-3141)	1129 (655-2848)	974 (588-1486)	1256 (764-2116)	1241 (814-1714)
Chlorophyll a (mg/m^3)	31.3 (7.4-83.7)	35.2 (4.6-72.1)	42.3 (4.2 236.2)	40.4 (7.5-262)	34.8 (3.9-59.4)	37.0 (9.2-58.9)
Surface Oxygen (mg/L)	7.4 (4.0-11.6)	7.6 (4.5-10.6)	5.5 (1.3-8.7)	6.3 (0.5-9.7)	7.9 (5.6-11.8)	8.0 (5.5-9.9)
Bottom Oxygen (mg/L)	4.1 (0.4-10.4)	4.1 (0.0-8.6)	2.1 (10.1-6.5)	2.5 (0.0-7.6)	2.8 (0.0-6.4)	4.3 (0.4-8.8)
Extinction Coefficient (K)	3.32 (1.94-5.22)	3.37 (2.46-4.35)	3.35 (1.97-5.36)	3.43 (1.58-6.02)	3.08 (2.02-4.01)	3.19 (2.29-4.50)
pH	6.3 (5.9-6.8)	6.6 (5.8-8.6)	6.1 (5.8-6.6)	6.1 (5.5-6.7)	6.7 (5.9-9.0)	6.4 (5.9-7.4)

Table 8. Annual mean values for water quality parameters measured in Lake Henderson, October 1982-August 1983. Range of values in parentheses.

Parameter	Panicum	Nuphar	Open water
Total Alkalinity (mg/L as $CaCO_3$)	55 (51-60)	57 (53-60)	56 (52-60)
Specific Conductance (µmho/cm^2 at 25°C)	129 (114-144)	137 (134-146)	136 (132-144)
Total Hardness (mg/L as $CaCO_3$)	58 (51-68)	59 (54-68)	59 (54-69)
Total Phosphorus (mg/m^3)	42.1 (14.7-94.7)	22.9 (10.4-34.9)	39.1 (16.0-74.9)
Total Nitrogen (mg/m^3)	950 (714-1999)	870 (630-1336)	911 (664-1285)
Chlorophyll a (mg/m^3)	22.3 (5.0-40.7)	15.2 (6.0-36.0)	25.0 (11.4-69.0)
Surface Oxygen (mg/L)	6.4 (3.8-11.0)	5.1 (2.0-8.5)	5.9 (3.6-9.5)
Bottom Oxygen (mg/L)	2.9 (0.3-5.3)	2.9 (0.9-5.9)	2.5 (0.1-8.0)
Extinction Coefficient (K)	4.10 (2.57-7.42)	2.99 (2.00-4.69)	2.36 (1.26-3.55)
pH	6.8 (6.4-7.2)	6.6 (6.4-7.0)	6.7 (6.5-7.1)

Table 9. Percent contribution of various sources to the total variance of water quality parameters, October 1982 - August 1983.

		Source of Variation			
Lake	Parameter	Habitat	Stations within habitat	Date	Error
Orange	Total alkalinity	0	27*	38*	35
Orange	Total nitrogen	6	3	46*	44
Orange	Total phosphorus	0	0	66*	34
Orange	Chlorophyll a	0	0	44*	56
Henderson	Total alkalinity	12*	2	78*	8
Henderson	Total nitrogen	0	5	38*	57
Henderson	Total phosphorus	23	24*	24*	29
Henderson	Chlorophyll a	15	9*	59*	18

* Significant ($p \leq 0.05$) source of variation by analysis of variance (PROC GLM, SAS Institute 1982) of $\log_{10}$ transformed data.

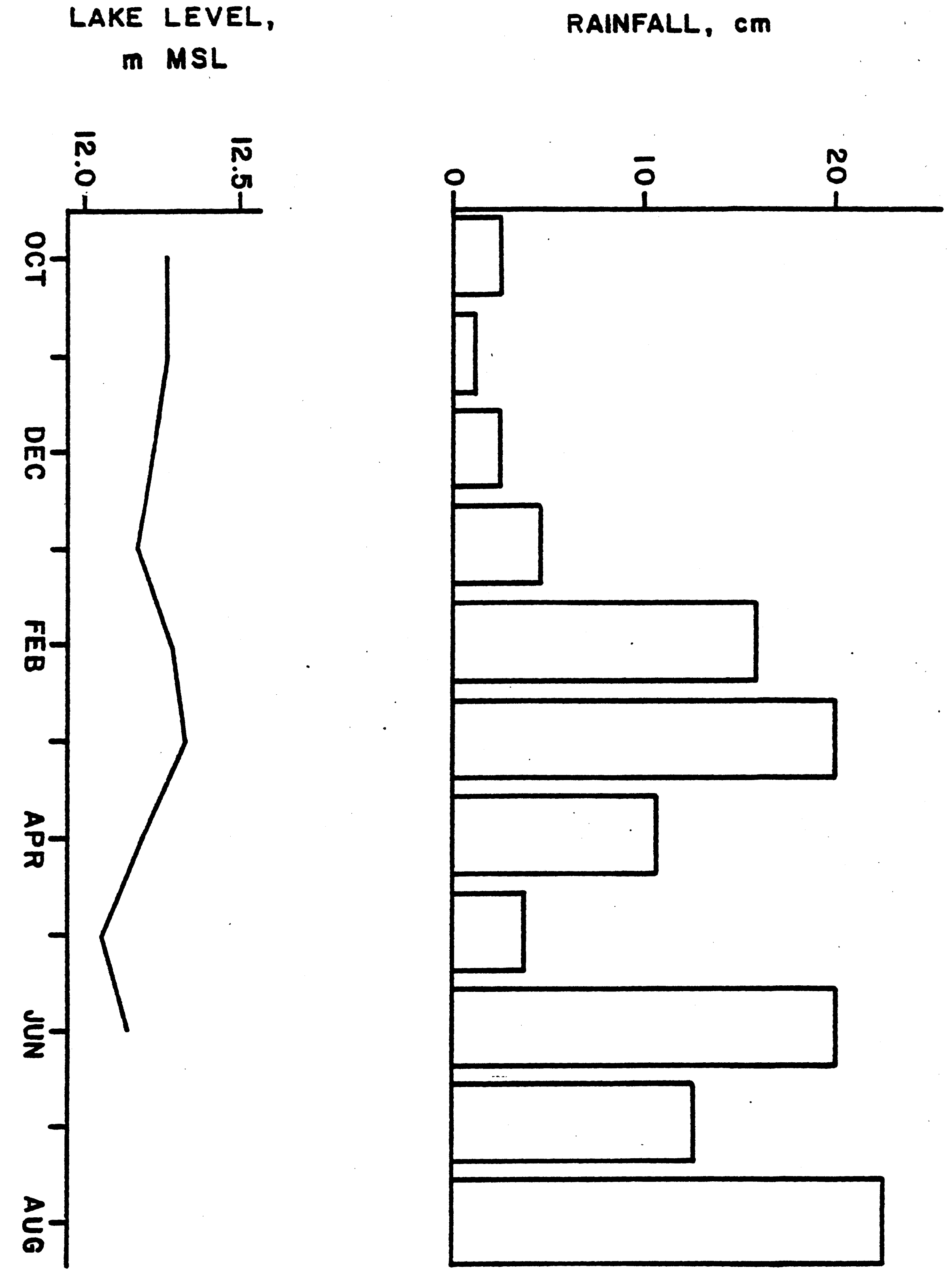

Figure 4. Rainfall and lake level, Lake Henderson, October 1982-August 1983.

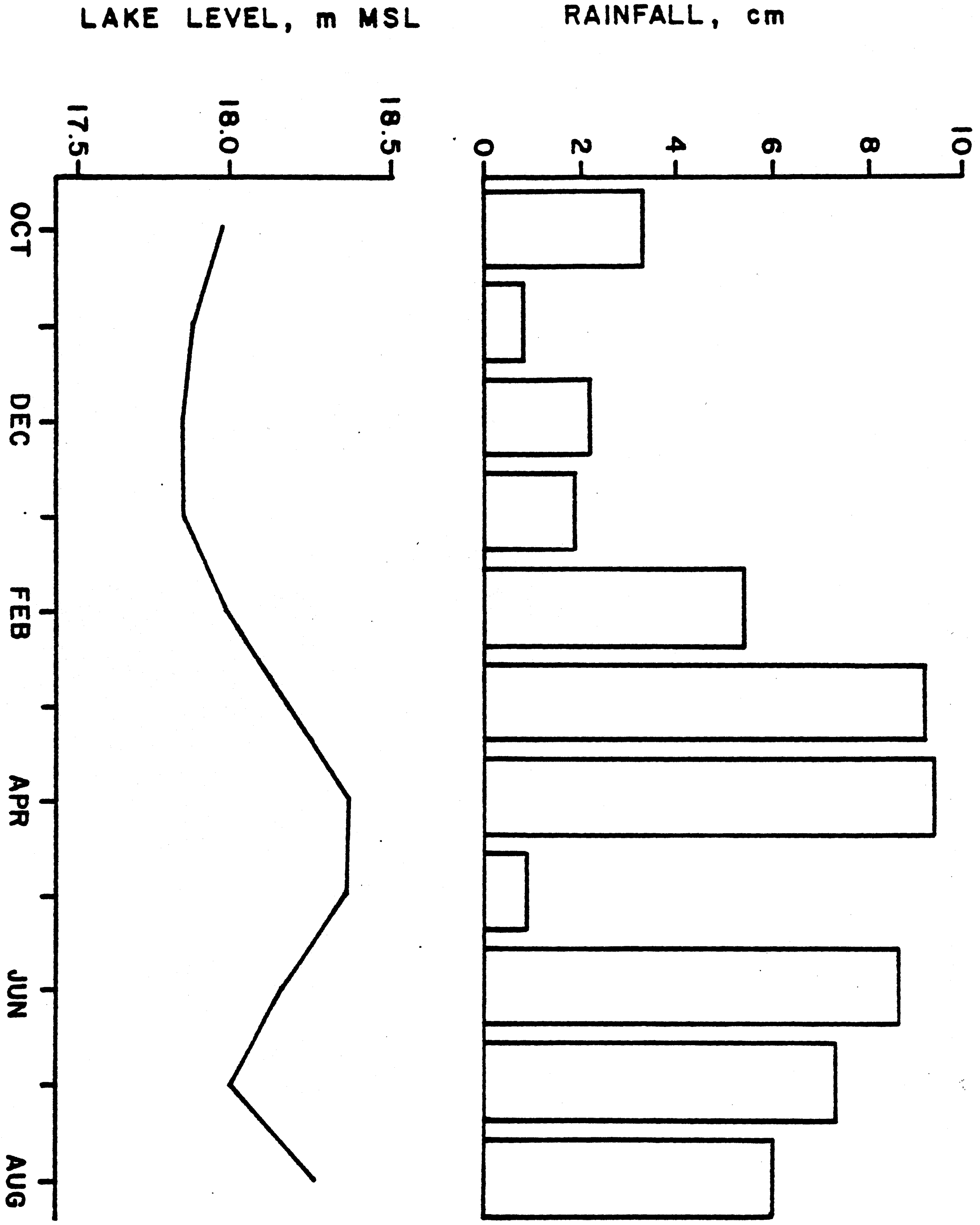

Figure 3. Rainfall and lake level, Orange Lake, October 1982-August 1983.

in Orange Lake. Landers (1982) found senescing macrophytes contributed significantly to dissolved nutrient levels.

PERIPHYTON

Macrophyte Comparison

In Orange Lake, periphyton biomass was highest on *Utricularia* and *Ceratophyllum* (Table 10). The submersed portion of *Eichhornia*, *Paspalidium*, and *Hydrilla* supported intermediate biomass of periphyton. Periphyton was least abundant on *Nuphar* stems. Seasonal fluctuations in periphyton biomass were variable among different species of host macrophytes (Table 11). Periphyton biomass on *Nuphar*, *Paspalidium* and *Hydrilla* declined from December through April, increased to peak biomass in June and declined in August. Biomass of periphyton on a *Ceratophyllum*, although based on limited number of samples, was relatively constant. Periphyton biomass on *Eichhornia* was low in April and June and high in February and August. Periphyton biomass on *Eichhornia* was also low in December, although only one sample was analyzed. Periphyton biomass on *Utricularia* was highest in June and August.

In Lake Henderson, periphyton biomass was highest on *Utricularia*, high on the submersed portion of *Pistia*, and intermediate on *Panicum* and *Eichhornia* (Table 10). *Nuphar* supported low periphyton biomass. Seasonal fluctuations in periphyton biomass were variable among different species of host macrophytes (Table 12), but similar to the trends in Orange Lake. Periphyton biomass on *Nuphar* and *Panicum* declined from December to April and increased during June and August. Periphyton biomass on *Eichhornia* declined slightly during December through April, increased in June and declined sharply in August. Limited estimates of periphyton biomass on *Utricularia* indicated peak biomass in June and low biomass in April.

A general trend shown in both lakes was greatest periphyton abundance on submergent plants, intermediate abundance on floating plants, and lowest abundance on emergent plants. A likely explanation for this trend is a

Table 10. Mean epiphytic macroinvertebrate density (individuals/kg wet weight plant) and biomass (mg dry weight/kg wet weight plant) and periphyton biomass (mg chlorophyll *a*/kg wet weight plant) on various macrophytes, October 1982-August 1983.

Lake	Macrophyte	Sample size	Macroinvertebrate density	Macroinvertebrate biomass	Periphyton biomass
Orange	*Eichhornia crassipes*	31	6651	2.256	39.3
Orange	*Nuphar luteum*	27	7	0.002	2.9
Orange	*Ceratophyllum demersum*	9	3792	0.680	163.3
Orange	*Hydrilla verticillata*	48	1235	0.715	37.1
Orange	Utricularia spp.	23	3286	1.117	126.1
Orange	*Paspalidium geminatum*	28	421	0.184	24.0
Henderson	*Pistia stratiotes*	4	7272	8.932	108.1
Henderson	*Eichhornia crassipes*	28	7545	3.165	28.0
Henderson	*Nuphar luteum*	15	62	0.012	5.3
Henderson	*Ceratophyllum demersum*	1	2414	0.816	
Henderson	*Utricularia* spp.	6	9122	3.455	177.1
Henderson	*Panicum hemitomon*	24	845	0.504	37.5

Table 11. Periphyton abundance (mg chlorophyll a/kg wet weight plant) on host macrophytes in Orange Lake, December 1982-August 1983. Numbers in parentheses are sample size and coefficient of variation (n, C.V.).

Macrophyte	Date Dec	Feb	Apr	Jun	Aug
Eichhornia	3.8 (1, -)	34.9 (5, 70)	14.7 (3, 33)	22.2 (6, 52)	49.8 (4, 144)
Nuphar	2.6 (6, 54)	1.3 (6, 123)	1.1 (3, 23)	5.0 (6, 48)	3.8 (6, 71)
Paspalidium	16.7 (6, 70)	2.8 (6, 61)	1.6 (4, 19)	58.8 (6, 59)	32.6 (6, 47)
Ceratophyllum		165.3 (1, -)		161.6 (2, 28)	164.1 (4, 44)
Hydrilla	68.4 (12, 71)	10.5 (11, 76)	10.0 (5, 66)	45.6 (6, 58)	37.1 (5, 78)
Utricularia	46.8 (3, 32)	59.0 (6, 58)	11.5 (1, -)	229.0 (3, 67)	229.1 (4, 27)

Table 12. Periphyton abundance (mg chlorophyll a/kg wet weight plant) on host macrophytes in Lake Henderson, December 1982-August 1983. Numbers in parentheses are sample size and coefficient of variation (n, C.V.).

Macrophyte	Date Dec	Feb	Apr	Jun	Aug
Pistia	40.8 (3, 96)	309.8 (1, -)			
Eichhornia	31.2 (4, 75)	29.8 (5, 79)	21.4 (5, 93)	48.1 (5, 85)	8.3 (5, 57)
Nuphar	6.5 (3, 46)	3.3 (3, 16)	3.0 (3, 80)	4.6 (3, 59)	8.8 (3, 10)
Panicum	64.3 (4, 66)	27.1 (4, 121)	31.5 (4, 62)	24.2 (4, 76)	38.4 (5, 71)
Utricularia	114.2 (1, -)		82.1 (2, 42)	300.5 (2, 85)	183.1 (1, -)

positive relationship between surface area for colonization and periphyton biomass. Several authors (e.g., Allen 1971, Berg 1977) have suggested the macrophytes provide nutrients to periphyton. Such a nutrient pathway may explain the abundance of periphyton attached to the submersed portions of floating plants. Temporal fluctuations in periphyton abundance on submersed and emergent macrophytes appear to have a seasonal basis, with peak abundance in the summer. Periphyton abundance on floating macrophytes were variable and showed no consistent seasonality. This variability may be related to the age of these macrophytes, which reproduce rapidly; new plants would likely have less abundant periphyton.

Habitat Comparisons

Variance component analysis (PROC VARCOMP, SAS Institute 1982) was used to evaluate sources of variation in periphyton abundance within lakes and analysis of variance (PROC GLM, SAS Institute 1982) was used to test for significant effects on periphyton abundance (Tables 13, 14). There was significant temporal variation in periphyton abundance in Orange Lake, but date accounted for 0% of the variance in periphyton abundance in Lake Henderson. Habitat and station within habitat accounted for nonsignificant proportions of the variance in periphyton abundance.

The lack of significant differences in periphyton abundance between habitats and the high variation among stations within habitats may be related to the large differences in periphyton abundance on different host macrophytes. Periphyton abundance was relatively low on *Panicum*, *Paspalidium*, and *Nuphar*. These macrophytes comprised the bulk of plant biomass in all habitats except the hydrilla habitat throughout our study. Conversely, periphyton abundance was high on floating and submersed plants. Although present at low biomass, these macrophytes can alter total periphyton abundance and increase variability among stations. Further, since biomass of these

Table 13. Percent contribution of various sources to the total variance of periphyton biomass, February 1983-August 1983.

	Source of Variation			
Lake	Habitat	Stations within habitat	Date	Error
Orange	0	11	45*	45
Henderson	9	8	0	83

* Significant ($p \leq 0.05$) source of variation by analysis of variance (PROC GLM, SAS Institute 1982) of logarithm$_{10}$ transformed data.

Table 14. Annual mean periphyton biomass (mg chlorophyll a/m^2) ± one standard deviation, February 1983-August 1983.

Lake	Habitat				
	Maidencane	Maidencane-hydrilla	Spatterdock	Spatterdock-hydrilla	Hydrilla
Orange	95 ± 50[a]	67 ± 31[a]	170 ± 218[a]	202 ± 139[a]	19 ± 22[a]
Henderson	197 ± 63[a]		75 ± 93 [a]		

[a] Means with the same letter, within one lake, are not significantly different ($p \leq 0.05$) by Waller-Duncan test (SAS Institute 1982) of logarithm_{10} transformed data.

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plants were temporally variable, temporal variation in total periphyton biomass, as observed, could be expected.

PHYTOPLANKTON

A total of 52 phytoplankton genera were recorded in Orange Lake (Table 15). This total included: Chlorophyta, 32 genera; Euglenophyta, 3 genera; Chrysophyta, 7 genera; Pyrrhophyta, 2 genera; Cryptophyta, 2 genera; and Cyanophyta, 6 genera. The bluegreen algae *Anabaena* and *Polycystis* and the cryptomonad *Cryptomonas* were most abundant in Orange Lake.

A total of 64 phytoplankton genera were recorded for Lake Henderson (Table 16). The phytoplankton community included: Chlorophyta, 35 genera; Euglenophyta, 3 genera; Chrysophyta, 13 genera; Pyrrhophyta, 2 genera; Cryptophyta, 2 genera; and Cyanophyta, 9 genera. Green algae were dominant in Lake Henderson. Abundant genera included *Polycystis*, *Melosira*, *Ankistrodesmus*, and *Scenedesmus*.

Variance component analysis (PROC VARCOMP, SAS Institute 1982) was used to examine sources of variation in phytoplankton abundance in each lake, and significant effects on phytoplankton abundance were evaluated by analysis of variance (PROC GLM, SAS Institute 1982). Temporal variation was a large and significant portion of the variation in phytoplankton density in both lakes (Table 17), indicating large seasonal fluctuations in phytoplankton abundance. Stations within habitat accounted for small, nonsignificant amounts of variation in phytoplankton density. This suggests the replicate stations of each habitat were valid replicates. Habitat type accounted for significant portions of the variation in phytoplankton density in Orange Lake. In Orange Lake, phytoplankton density was highest and statistically similar in the open water, maidencane-hydrilla, and hydrilla habitats (Table 18). Phytoplankton density was lowest in the spatterdock and spatterdock-hydrilla habitats. Although not statistically significant, a similar trend was observed in Lake Henderson.

Table 15. Annual mean phytoplankton density (cells x 10^3/liter), Orange Lake, October 1982-August 1983.

	Habitat					
Taxon	Maidencane	Maidencane-hydrilla	Spatterdock	Spatterdock-hydrilla	Hydrilla	Open water
Chlorophyta						
Chlamydomonas	3				10	
Eudorina	6	29	5	4	7	
Volvox	3					
Haematococcus	68	54	46	32	45	21
Oedogonium	28	72		17	47	
Schroederia	20	18	2	3	20	15
Pediastrum	5			3	8	3
Chlorella	1				2	
Oocystis	18		2	9	5	11
Nephrocytium	1					
Ankistrodesmus	98	131	155	140	148	108
Scenedesmus	45	108	29	33	43	53
Actinastrum	14	23	22		3	8
Zygnema	14	9				
Netrium	4					
Closterium	55	53	8	38	53	50
Micrasterias	9	9	1	2		
Cosmarium	46	158	31	37	103	29
Staurastrum	309	292	113	184	297	275
Onychonema	91	13	38	24		
Asterococcus	15	3				5
Tetraedon		1	6	6		7
Crucigenia		2				
Ulothrix			22			
Tetrastrum			1			2
Mougeotia			1		5	
Spondylosium			19	3		
Cosmocladium			27	4	2	
Gonium				3		
Spirogyra				4		
Microspora					1	
Stephanosphaera						9

Table 15. Continued.

Taxon	Habitat					
	Maidencane	Maidencane-hydrilla	Spatterdock	Spatterdock-hydrilla	Hydrilla	Open water
Euglenophyta						
<u>Euglena</u>	7	5	16	3	6	
<u>Phacus</u>	2	2	3	15		
<u>Trachelomonas</u>	4	13				2
Chrysophyta						
<u>Dinobryon</u>	1	54	61	15		8
<u>Mallomonas</u>	15	25	18	6	10	28
<u>Bacillariophyceae</u>	158	262	95	100	206	97
<u>Melosira</u>	165	195	49	77	190	177
<u>Rhizosolenia</u>	3	37	10	2	22	23
<u>Atteya</u>	8	8	2	3	4	6
<u>Gomphonema</u>		2				
<u>Ophiocytium</u>						9
Pyrrhophyta						
<u>Peridinium</u>	1	13	3	13	2	2
<u>Ceratium</u>			5	2		
Cryptophyta						
<u>Cryptomonas</u>	638	938	370	442	540	552
<u>Cyanomonas</u>			84	7		
Cyanophyta						
<u>Polycystis</u>	492	804	439	395	563	586
<u>Merismopedia</u>	4	10				
<u>Oscillatoria</u>	193	325	137	79	529	510
<u>Anabaena</u>	1604	1488	726	652	1452	2282
<u>Spirulina</u>		12				
<u>Aphanizomenon</u>					4	
Unidentified cells	564	530	452	472	547	469

Table 16. Annual mean phytoplankton density (cells x 10^3/liter), Lake Henderson, October 1982-August 1983.

Taxon	Habitat		
	Maidencane	Spatterdock	Open water
Chlorophyta			
<u>Chlamydomonas</u>	17		
<u>Eudorina</u>		11	23
<u>Haematococcus</u>	135	111	117
<u>Schroederia</u>	11		
<u>Pediastrum</u>	15	8	59
<u>Chlorella</u>	70	2	58
<u>Oocystis</u>	40	7	18
<u>Nephrocytium</u>	1		
<u>Ankistrodesmus</u>	616	313	575
<u>Scenedesmus</u>	546	171	394
<u>Actinastrum</u>	23	18	5
<u>Zygnema</u>	2	3	5
<u>Netrium</u>	12	5	8
<u>Closterium</u>	25	53	44
<u>Micrasterias</u>	11		
<u>Cosmarium</u>	308	71	130
<u>Staurastrum</u>	23	29	21
<u>Onychonema</u>		15	
<u>Tetraedon</u>	46	15	18
<u>Crucigenia</u>	116	167	203
<u>Ulothrix</u>			5
<u>Tetrastrum</u>	19	18	2
<u>Mougeotia</u>		17	20
<u>Cosmocladium</u>		42	33
<u>Gonium</u>	39	16	34
<u>Pandorina</u>	3	4	16
<u>Golenkinia</u>	10		17
<u>Selenastrum</u>	3	5	3
<u>Polydriopsis</u>	12		4
<u>Coccomonas</u>		3	
<u>Quadrigula</u>		1	9
<u>Kirchneriella</u>		7	
<u>Binuclearia</u>			13
<u>Euastrum</u>			11
<u>Gloeocystis</u>			2
Euglenophyta			
<u>Euglena</u>	5	21	29
<u>Phacus</u>	16	18	19
<u>Trachelomonas</u>	2	5	25
Chrysophyta			
<u>Dinobryon</u>	12	43	31
Bacillariophyceae	313	261	337
<u>Melosira</u>	510	418	486
<u>Rhizosolenia</u>	56	60	76
<u>Atteya</u>	19	29	25
<u>Ophiocytium</u>		8	

Table 16. Continued.

Taxon	Habitat Maidencane	 Spatterdock	 Open water
Chrysophyta (continued)			
Ochromonas	11		9
Fragilaria	1		
Asterionella	3	3	9
Cocconeis	4		
Synedra		2	
Tribonema			11
Hydrosera			9
Pyrrhophyta			
Peridinium	61	39	45
Ceratium	8	5	12
Cryptophyta			
Cryptomonas	234	442	196
Cyanomonas	48		57
Cyanophyta			
Polycystis	964	567	787
Merismopedia	177	82	154
Oscillatoria	380	140	241
Anabaena	172	281	297
Spirulina	5		
Aphanizomenon	12	46	
Chroococcus	1	3	
Lyngbya	14	5	3
Schizothrix			1
Unidentified cells	1048	1022	1152

Table 17. Percent contribution of various sources to the total variance of phytoplankton cell counts, October 1982 - August 1983.

Lake	Source of Variation Habitat	 Stations within habitat	 Date	 Error
Orange	16*	0	56*	27
Henderson	0	3	75*	22

* Significant ($p \leq 0.05$) source of variation by analysis of variance (PROC GLM, SAS Institute 1982) of logarithm$_{10}$ transformed data.

Table 18. Annual mean phytoplankton cell density (cells x 10^3/liter) ± one standard deviation, October 1982 - August 1983.

Lake	Habitat					
	Open water	Maidencane	Maidencane-hydrilla	Spatterdock	Spatterdock-hydrilla	Hydrilla
Orange	6938 ± 1221^a	4796 ± 875^b	6018 ± 1537^a	2986 ± 659^c	2774 ± 601^c	4886 ± 354^{a,b}
Henderson	6147 ± 538^a	6546 ± 2014^a		4532 ± 992^a		

a,b,c Means with the same letter, within one lake, are not significantly ($p \leq 0.05$) different by Waller-Duncan test (SAS Institute 1982) of logarithm_{10} transformed data.

The low phytoplankton density in the spatterdock and spatterdock-hydrilla habitats in Orange Lake, i.e., the habitats with highest macrophyte biomass, was similar to the findings of Hasler and Jones (1949), Goulder (1969) and Osborne et al. (1982), who reported inverse relations between plant biomass and phytoplankton abundance. The lack of significant differences in phytoplankton abundance between habitats in Lake Henderson, despite the high plant biomass in the maidencane habitat, does not support the inverse relationship between plant biomass and phytoplankton abundance. This is possibly a result of sampling methodology. Due to the high stem density in the Lake Henderson maidencane habitat, phytoplankton samples were collected at the open water edge of the maidencane to avoid collecting periphyton in the phytoplankton sample. By this methodology, the sample may be more representative of the open water habitat. The Lake Henderson data does, however, indicate lower phytoplankton density in the spatterdock habitat than in open water.

Open water stations in Orange Lake consistently had higher phytoplankton cell counts than open water stations in Lake Henderson, indicating more eutrophic conditions in Orange Lake (Likens 1975). The dominance of bluegreen algae in Orange Lake also indicates more eutrophic conditions in Orange Lake than in Lake Henderson.

ZOOPLANKTON

Rotifers were numerically dominant in both lakes (Tables 19, 20). Number of rotifer genera in different habitat types ranged from 17-26 and 13-22 in Orange Lake and Lake Henderson, respectively. Prevalent genera in Orange Lake were *Keratella* and *Trichocerca*. In Lake Henderson, *Polyarthra* and *Keratella* were numerically dominant. Number of Cladocera genera in different habitat types ranged from 7-12 and 9-11 in Orange Lake and Lake Henderson, respectively. *Bosmina* and *Ceriodaphnia* were the most abundant cladocerans in both lakes.

Variance component analysis (PROC VARCOMP, SAS Institute 1982) was used to estimate sources of variation in zooplankton density in each lake and analysis of variance (PROC GLM, SAS Insstitute 1982) was used to evaluate significant effects on zooplankton density. There were significant effects on total zooplankton, rotifers, cladocerans, copepods and nauplii densities in Lake Henderson (Table 21). These results indicate large temporal variation in zooplankton density in both lakes. Except for Cladocera in Orange Lake, station within habitat variations were not significant, indicating the replicate stations of each habitat were valid replicates. Habitat accounted for significant amounts of the variation in density of rotifers, cladocerans and total zooplankton in Orange Lake and rotifers and total zooplankton in Lake Henderson. Densities of the zooplankton groups were variable in the different habitats in both lakes; however, high densities of all taxonomic groups were consistently collected in the open water habitat (Table 22). Further, when zooplankton density was significantly different among habitats, density was always low in the spatterdock-hydrilla habitat in Orange Lake and the maidencane habitat in Lake Henderson.

In light of research demonstrating direct correlations between lake trophic status and zooplankton abundance (Patalas 1972, Noonan 1979, McCauley and Kalff 1981), the

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Table 19. Annual mean zooplankton density (individuals/liter), Orange Lake, October 1982-August 1983.

	Habitat					
Taxon	Maidencane	Maidencane-hydrilla	Spatterdock	Spatterdock-hydrilla	Hydrilla	Open water
Arthropoda						
Diaphanosoma	4.6	3.5	1.6	1.4	3.0	2.0
Sida	0.2	<0.1				
Daphnia	1.1	1.5	1.3	0.7	3.0	2.5
Ceriodaphnia	6.9	9.6	3.7	3.6	5.2	3.4
Chydorus	0.4	0.9	0.8	0.3	0.7	0.1
Alona	1.1	1.7	1.4	0.7	1.5	0.1
Eurycercus	0.1					
Bosmina	9.9	16.9	10.5	4.6	14.1	17.0
Macrothrix	0.1	0.4	0.1	0.1	1.5	
Holopedium	<0.1				0.2	<0.1
Simocephalus		<0.1			0.1	
Camptocercus		0.3		0.1	0.7	
Alonopsis		0.2				
Alonella				0.1	<0.1	
Ilyocryptus					0.6	
Eucopepoda	24.9	30.9	21.3	26.0	29.6	12.2
Rotifera						
Brachionus	0.4	0.6	0.3	0.3	0.5	0.3
Euchlanis	0.3	0.4	0.5	0.4	0.2	
Kellicottia	1.6	1.1	1.3	0.5	2.3	1.0
Keratella	29.6	49.8	39.9	33.3	39.5	25.3
Macrochaetus	0.2	0.7		0.1	1.4	
Platyias	<0.1	0.8	0.2	0.3	0.3	0.1
Trichotria	<0.1	0.1		<0.1	<0.1	
Lepadella	1.3	1.3	1.0	0.9	1.3	0.1
Anuraeopsis	0.2	0.2			0.4	
Lecane	2.1	2.4	3.0	1.8	3.8	0.1
Monostyla	2.9	3.3	2.7	2.4	4.1	0.2
Cephalodella	<0.1	0.1				
Monommata	0.1	0.1	0.4	0.2	0.2	0.2

Table 19. Continued.

Taxon	Maidencane	Maidencane-hydrilla	Spatterdock	Spatterdock-hydrilla	Hydrilla	Open water
Rotifera (continued)						
Trichocerca	30.5	43.3	23.0	25.8	45.2	37.7
Ascomorpha	0.1					
Asplanchna	2.3	5.1	2.3	2.6	3.4	1.5
Ploesoma	0.1	0.6		<0.1	0.1	
Polyarthra	17.3	15.7	21.0	16.6	14.1	10.5
Synchaeta	5.3	11.6	15.9	9.3	9.7	7.4
Filinia	1.6	5.5	4.8	1.4	7.6	5.6
Pompholyx	0.1		0.7		0.2	
Testudinella	1.0	0.5	0.5	0.3	0.3	0.1
Trochosphaera	0.1		0.1			
Hexarthra	0.9	1.3	0.8	1.1	0.9	0.4
Collotheca	13.8	16.4	16.4	10.9	14.0	14.0
Rotaria	0.8	1.2	0.9	1.3	0.1	0.1
Mytilina		0.4		0.2	0.5	
Dipleuchlanis		0.1				

Table 20. Annual mean zooplankton density (individuals/liter), Lake Henderson, October 1982-August 1983.

Taxon	Maidencane	Spatterdock	Open water
Arthropoda			
Diaphanosoma	1.2	0.5	0.1
Sida	0.5	<0.1	
Daphnia	0.1	0.4	0.2
Ceriodaphnia	2.9	1.8	0.5
Chydorus	0.7	0.3	<0.1
Alona	1.2	0.2	<0.1
Bosmina	12.1	20.7	17.1
Macrothrix	1.4	0.4	0.1
Holopedium			0.1
Simocephalus	2.4		
Camptocercus	0.2	0.1	
Alonella		<0.1	
Pleuroxus	0.1	0.1	0.1
Eucopepoda	15.7	15.1	9.5
Rotifera			
Brachionus	3.4	2.2	6.5
Kellicottia	1.7	3.2	7.9
Keratella	10.1	12.4	26.2
Macrochaetus	0.1		
Platyias	<0.1		
Trichotria	0.1	0.2	
Lepadella	0.6	1.1	0.9
Lecane	1.7	1.0	0.9
Monostyla	2.0	1.3	0.4
Monommata	0.1		
Trichocerca	2.7	1.5	3.2
Asplanchna	2.2	5.9	9.0
Polyarthra	42.7	36.3	50.9
Synchaeta	3.7	5.7	4.3
Filinia	0.1		0.4
Testudinella	0.1	0.1	
Hexarthra	2.4	8.7	5.2
Collotheca	5.0	16.9	19.7
Rotaria	0.6	0.1	
Mytilina	0.2	0.1	
Notommata	0.2		
Ascomorphella	0.2		

Table 21. Percent contribution of various sources to the total variance of zooplankton density, October 1982 - August 1983.

Lake	Taxon	Source of Variation Habitat	Stations within habitat	Date	Error
Orange	Rotifera	3*	0	64*	34
Orange	Cladocera	12*	13*	45*	30
Orange	Eucopepoda	2	0	67*	31
Orange	Nauplii	1	5	58*	36
Orange	Total zooplankton	5*	0	70*	25
Henderson	Rotifera	15*	0	37*	49
Henderson	Cladocera	0	0	10	90
Henderson	Eucopepoda	0	0	19*	81
Henderson	Nauplii	0	4	7	89
Henderson	Total zooplankton	12*	0	31*	58

* Significant ($p \leq 0.05$) source of variation by analysis of variance (PROC GLM, SAS Institute 1982) of logarithm$_{10}$ transformed data.

Table 22. Annual mean zooplankton density (individuals/liter) ± one standard deviation, October 1982 - August 1983.

Lake	Taxon	Habitat Open water	Maidencane	Maidencane-hydrilla	Spatterdock	Spatterdock-hydrilla	Hydrilla
Orange	Rotifera	143 ± 177 [a]	116 ± 135 [a,b]	157 ± 197 [a]	136 ± 181 [a]	112 ± 164 [b]	169 ± 296 [a]
Orange	Cladocera	32 ± 31 [a]	25 ± 19 [a]	33 ± 25 [a]	19 ± 31 [b]	13 ± 15 [b]	35 ± 19 [a]
Orange	Eucopepoda	16 ± 14 [a]	26 ± 23 [a]	29 ± 26 [a]	21 ± 20 [a]	28 ± 32 [a]	31 ± 28 [a]
Orange	Nauplii	42 ± 34 [a]	68 ± 110 [a]	46 ± 30 [a]	48 ± 33 [a]	41 ± 38 [a]	57 ± 41 [a]
Orange	Total zooplankton	233 ± 205 [a]	235 ± 174 [a]	265 ± 214 [a]	224 ± 213 [a]	194 ± 201 [b]	292 ± 301 [a]
Henderson	Rotifera	136 ± 85 [a]	80 ± 63 [b]		109 ± 67 [a]		
Henderson	Cladocera	18 ± 19 [a]	22 ± 10 [a]		26 ± 25 [a]		
Henderson	Eucopepoda	10 ± 8 [a]	10 ± 6 [a]		12 ± 12 [a]		
Henderson	Nauplii	43 ± 32 [a]	34 ± 14 [a]		45 ± 27 [a]		
Henderson	Total zooplankton	198 ± 85 [a]	146 ± 71 [b]		192 ± 97 [a,b]		

[a,b] Means with the same letter, within one lake and taxon, are not significantly ($p \leq 0.05$) different by Waller-Duncan test (SAS Institute 1982) of logarithm$_{10}$ transformed data.

higher zooplankton density indicates Orange Lake is more eutrophic than Lake Henderson. The numerical dominance of rotifers in both lakes is similar to findings in other central Florida lakes (Nordlie 1976, Blancher 1979, Schmitz 1980).

There was a trend toward higher zooplankton abundance in open water and lower zooplankton abundance in the habitats with highest plant biomass in Orange Lake and Lake Henderson. This trend follows the inverse relation between plant biomass and zooplankton abundance reported by Pennak (1966), Schmitz (1980) and Osborne, et al. (1982). This trend also parallels the inverse relationship between plant biomass and phytoplankton density discussed previously.

HYDROSOIL MACROINVERTEBRATES

Variance component analysis (PROC VARCOMP, SAS Institute 1982) and analysis of variance (PROC GLM, SAS Institute 1982) indicated date accounted for large portions of variation in density and biomass of hydrosoil macroinvertebrates (Table 23). Station within habitat did not account for significant proportions of the variance, indicating the stations were valid replicates for the habitats. Significant portions of variance were accounted for by habitat.

In Orange Lake, highest density of benthic macroinvertebrates was collected in the maidencane, maidencane-hydrilla, spatterdock, and spatterdock-hydrilla habitats and lowest density was collected in the open water and hydrilla habitats (Table 24). Highest hydrosoil macroinvertebrate biomass were collected in the maidencane, maidencane-hydrilla, and spatterdock habitats; lowest biomass was collected in the hydrilla and open water habitats. Insects, primarily chironomid and chaoborid larvae, were the dominant taxa by weight and number in all habitats (Table 25). Oligochaetes were present in the second highest density in all habitats. High biomass of gastropods and crustaceans were collected in most habitats.

In Lake Henderson, highest density of hydrosoil macroinvertebrates was collected in the open water habitat and lowest density was collected in the spatterdock habitat (Table 24). Highest biomass of hydrosoil macroinvertebrates was present in the open water and maidencane habitats. Insects, primarily chironomid and chaoborid larvae were the most prevalent invertebrates by number (Table 26). High densities of oligochaetes, molluscs, and Hyalella were also present in all habitats. Molluscs were the most abundant by weight in all habitats.

Hydrosoil macroinvertebrate biomass was higher in all habitats in Lake Henderson than in Orange Lake. This

Table 23. Percent contribution of various sources to the total variance of hydrosoil macroinvertebrate density (individuals/m^2) and biomass (mg dry weight/m^2), October 1982-August 1983.

		Source of Variation			
Lake	Variable	Habitat	Stations within habitat	Date	Error
Orange	Density	8*	1	59*	32
Orange	Biomass	9	0	53*	39
Henderson	Density	46*	5	22*	26
Henderson	Biomass	29*	3	24*	45

* Significant ($p \leq 0.05$) source of variation by analysis of variance (PROC GLM, SAS Institute 1982) of logarithm_{10} transformed data.

Table 24. Annual mean hydrosoil macroinvertebrate density (individuals/m^2) and biomass (mg dry weight/m^2) ± one standard deviation, October 1982-August 1983.

		Habitat					
Lake	Variable	Open water	Maidencane	Maidencane-hydrilla	Spatterdock	Spatterdock-hydrilla	Hydrilla
Orange	Density	318 ± 156 ^{c}	982 ± 312 ^{a}	1005 ± 99^{a}	733 ± 209^{a}	662 ± 200^{a,b}	509 ± 70 ^{b,c}
Orange	Biomass	90 ± 47 ^{d}	544 ± 149 ^{a}	367 ± 56^{a,b}	284 ± 141^{a,b,c}	266 ± 141^{b,c}	218 ± 426^{c,d}
Henderson	Density	1523 ± 362 ^{a}	550 ± 175 ^{b}		260 ± 23 ^{c}		
Henderson	Biomass	30725 ± 4405^{a}	178705 ± 2965^{a}		1534 ± 319^{b}		

a,b,c,d Means with the same letter, within one lake and variable, are not significantly different ($p \leq 0.05$) by Waller-Duncan test (SAS Institute 1982) of logarithm_{10} transformed data.

Table 25. Annual mean hydrosoil macroinvertebrate density (individuals/m^2) and biomass (mg dry weight/m^2), Orange Lake, October 1982-August 1983.

	Habitat											
	Open water		Maidencane		Maidencane-hydrilla		Spatterdock		Spatterdock-hydrilla		Hydrilla	
Taxon	Density	Biomass	Density	Biomass	Density	Biomass	Density	Biomass	Density	Biomass	Density	Biomass
Platyhelminthes	<1	1	2	<1	<1	<1			<1	<1		
Turbellaria	<1	1	2	<1	<1	<1			<1	<1		
Aschelminthes							<1	<1	<1	<1		
Nematoda							<1	<1	<1	<1		
Annelida	49	11	178	81	149	69	89	24	33	18	53	12
Oligochaeta	49	11	168	46	134	31	78	11	29	5	52	12
Hirudinea			10	36	15	39	11	13	4	13	1	<1
Mollusca	7	<1	15	215	28	79	1	3	6	89	12	97
Gastropoda	7	<1	9	150	26	79	1	2	4	79	11	97
Pelecypoda			6	65	2	<1	<1	1	2	9	1	<1
Arthropoda	260	76	780	259	826	216	632	255	617	157	444	107
Crustacea	7	3	105	58	112	56	49	69	37	22	36	21
Cladocera			9	1	47	4	<1	<1	5	<1	<1	<1
Eucopepoda			3	<1	2	<1						
Podocopa			2	<1	<1	<1	15	<1			<1	<1
Amphipoda	7	3	89	23	60	15	28	9	31	9	35	14
<u>Hyalella</u>	7	3	89	23	60	15	28	9	31	9	35	14
Decapoda			2	34	3	37	6	60	1	12	1	7
<u>Palaemonetes</u>			2	34	3	37	6	60	1	12	1	7
Arachnoidea	<1	<1	<1	<1								
Hydracarina	<1	<1	<1	<1								
Insecta	253	73	675	201	714	160	587	186	580	135	408	86
Ephemeroptera			<1	<1	<1	<1			<1	1	1	<1
<u>Caenis</u>			<1	<1					<1	<1	<1	<1
Odonata			5	61	3	19	5	44	6	18	2	1
<u>Ischnura</u>					<1	1	<1	<1	2	1		
<u>Enallagma</u>			5	21	3	11	2	7	2	11	2	1
<u>Didymops</u>							1	4				
<u>Libellula</u>					<1	1	1	3				
<u>Tramea</u>							1	4				
<u>Pachydiplax</u>			<1	7			<1	6	1	6		
<u>Pantala</u>			<1	19			<1	18				
<u>Anax</u>					<1	3						
<u>Somatochlora</u>							<1	1				
Hemiptera	<1	<1	5	2	1	<1	7	3	1	<1	1	<1
<u>Trichocorixa</u>			3	1	1	<1	<1	<1	<1	<1	1	<1
<u>Gerris</u>			2	<1								
<u>Limnogonus</u>									<1	<1		
<u>Mesovelia</u>	<1	<1					1	<1	1	<1		

Table 25. Continued.

	Habitat											
	Open water		Maidencane		Maidencane-hydrilla		Spatterdock		Spatterdock-hydrilla		Hydrilla	
Taxon	Density	Biomass	Density	Biomass	Density	Biomass	Density	Biomass	Density	Biomass	Density	Biomass
Lepidoptera			1	1	1	<1			1	<1	11	4
<u>Parapoynx</u>			1	1	1	<1			1	<1	11	4
Coleoptera							17	45	9	22	2	<1
<u>Hydrochus</u>							<1	4	<1	<1		
<u>Donacia</u>							11	35	9	22		
<u>Galerucella</u>											2	<1
<u>Hydroporus</u>							6	6				
Trichoptera			28	7	33	11	4	3	18	5	10	3
<u>Oxyethira</u>			<1	<1	2	<1	<1	<1	4	<1		
<u>Orthotrichia</u>			<1	<1	1	<1	<1	<1	2	<1		
<u>Leptocerus</u>			<1	<1	<1	<1	2	1	3	2	1	<1
<u>Triaenodes</u>					2	<1	<1	<1				
<u>Oecetis</u>			<1	<1			1	<1	1	<1	<1	<1
<u>Ceraclea</u>							<1	<1	<1	<1		
<u>Nyctiophylax</u>									3	<1		
<u>Neureclipsis</u>									4	<1		
<u>Polycentropus</u>			28	6	28	10	<1	<1	1	<1	9	2
Diptera	253	73	636	129	676	129	556	92	545	88	380	77
Chironomidae larvae	28	11	187	37	140	29	153	30	163	25	63	10
Chironomidae pupae	2	<1	9	3	3	1	3	1			2	<1
<u>Palpomyia</u>									1	<1		
<u>Chaoborus</u>	223	62	440	89	533	99	397	55	380	62	312	66
Stratiomyidae							3	5	1	2		
<u>Tipula</u>											<1	<1
Colembola							<1	<1	<1	<1	1	<1
<u>Isotomurus</u>							<1	<1	<1	<1	1	<1

Table 26. Annual mean hydrosoil macroinvertebrate density (individuals/m^2) and biomass (mg dry weight/m^2), Lake Henderson, October 1982-August 1983.

	Habitat					
	Open water		Maidencane		Spatterdock	
Taxon	Density	Biomass	Density	Biomass	Density	Biomass
Platyhelminthes	2	<1	2	2		
Turbellaria	2	<1	2	2		
Aschelminthes	<1	<1				
Nematoda	<1	<1				
Annelida	230	64	182	137	43	13
Oligochaeta	228	58	176	42	42	4
Hirudinea	2	7	6	95	1	10
Mollusca	84	30460	100	178348	16	1239
Gastropoda	37	10177	51	15607	13	1209
Pelecypoda	47	20283	49	162741	3	30
Arthropoda	1207	199	261	217	198	301
Crustacea	19	8	84	166	21	39
Cladocera	<1	<1	1	<1	<1	<1
Eucopepoda	2	1	<1	<1	2	<1
Podocopa	1	<1			<1	<1
Amphipoda	16	3	74	13	17	5
Hyalella	16	3	74	13	17	5
Decapoda	<1	4	9	153	2	34
Palaemonetes	<1	4	9	153	2	34
Arachnoidea			1	<1		
Hydracarina			1	<1		
Insecta	1188	191	176	50	177	262
Ephemeroptera			<1	<1	<1	<1
Caenis			<1	<1	<1	<1
Odonata			1	8	1	163
Ischnura			1	4		
Agria			<1	1		
Pachydiplax			<1	2	1	51
Pantala			<1	2		
Perithemis					<1	101
Somatochlora					<1	11
Hemiptera			1	<1	1	<1
Mesovelia			<1	<1	1	<1
Lepidoptera			<1	<1		
Coleoptera			<1	<1	8	36
Laccobius					2	3
Donacia					2	9
Suphisellus					<1	<1
Pronoterus					<1	2
Hydroporus					4	2
Trichoptera			5	2	2	<1
Orthotrichia			4	<1	1	<1
Leptocerus					1	<1
Oecetis			1	1	<1	<1

Table 26. Continued.

	Habitat					
	Open water		Maidencane		Spatterdock	
Taxon	Density	Biomass	Density	Biomass	Density	Biomass
Diptera	1187	191	167	39	165	62
Chironomidae adults			1	<1		
Chironomidae larvae	86	25	58	14	98	52
Chironomidae pupae	4	3	3	2	1	<1
Palpomyia	2	1				
Probezzia	2	2	<1	<1		
Chaoborus	1093	161	105	21	66	10
Tipula			<1	<1		
Collembola	1	<1	2	<1	<1	<1
Isotomurus			2	<1	<1	<1
Podura	1	<1				

interlake difference was primarily due to the abundance of large molluscs in Lake Henderson. Density was higher in the open water habitat in Lake Henderson than in Orange Lake.

High densities and biomass of hydrosoil macroinvertebrates in Orange Lake in the maidencane, maidencane-hydrilla and spatterdock habitats suggest aquatic vegetation was an important factor determining hydrosoil macroinvertebrate distribution. Similar findings were reported by Wetzel (1975) and Shireman et al. (1983). Vascular plants and the litter and periphyton associated with them serve as major food sources for many hydrosoil macroinvertebrates (Scott and Osborne 1981), thus allowing for a greater biomass and diversity of these organisms in vegetated habitats. Heterogeneity of the bottom substrate is also increased by root systems of aquatic plants, increasing the amount of suitable habitat for some hydrosoil species. The low densities and biomass of hydrosoil macroinvertebrates in the open water and hydrilla habitats in Orange Lake are likely due to the thick muck and silt layer, and resulting oxygen deficiency, found on the bottom of these habitats. This makes for relatively homogeneous conditions. This homogeneity of the profundal environment, coupled with low oxygen and limited resource availability, result in low species diversity and biomass (Wetzel 1975).

Hydrosoil macroinvertebrate density in Lake Henderson was highest in the open water habitat due to the high abundance of dipterans, mainly chaoborid larvae, collected there. Diversity was extremely low for this habitat suggesting that for most types of hydrosoil macroinvertebrates, deep open water zones were undesirable habitats. Chaoborus are predaceous on small crustaceans and insects in the water column (Pennak 1978), so they would find this type of habitat more desirable than those invertebrates that are strictly bottom feeders. The open water and maidencane habitats had the highest biomass due mainly to the presence of large molluscs in these areas.

These habitats had a relatively firm bottom, which provided a suitable habitat for pelecypods and gastropods (Pennak 1978). The spatterdock habitat, on the other hand, had a soft muck bottom. The large volume of hydrosoil occupied by Nuphar rhizomes in the Lake Henderson spatterdock habitat may also have contributed to lower hydrosoil macroinvertebrate abundance.

All habitats in Lake Henderson had higher biomass of hydrosoil macroinvertebrates than the habitats in Orange Lake due mostly to the presence of large molluscs in Lake Henderson. The muck and silt bottom of Orange Lake was not suitable for habitation by molluscs, so these animals were relatively scarce in this lake. Densities of hydrosoil macroinvertebrates were higher in the Orange Lake maidencane and spatterdock habitats than in similar habitats in Lake Henderson. The relatively higher volume and density of macrophyte roots in Lake Henderson plant communities reduced the amount of habitable hydrosoil per square meter of bottom, and thus reduced hydrosoil macroinvertebrate density in these habitats. Hydrosoil macroinvertebrate density was much higher in the Lake Henderson open water habitat than that in Orange Lake due mainly to the physical conditions of the lake bottom. The flocculent bottom of Orange Lake was not conducive to supporting large populations of macroinvertebrates. The conditions of high turbidity and low oxygen found in the profundal zones of Orange Lake were not present in Lake Henderson, allowing this lake to have a more productive hydrosoil community.

Bottom substrate and macrophyte abundance influenced the diversity and density of hydrosoil macroinvertebrate communities. Our findings indicate diversity was higher in vegetated habitats than in nonvegetated habitats. Macrophytes directly or indirectly provide a food source for most hydrosoil macroinvertebrates, as well as providing heterogeneity to the bottom environment. In muck bottom lakes, such as Orange Lake, macrophytes also tend to stabilize and improve bottom conditions for hydrosoil macroinvertebrates. On the other hand, thick stands of emergent vegetation may limit hydrosoil macroinvertebrate densities as a result of large rhizomes and dense root masses reducing the area and volume of habitable hydrosoil. This suggests that communities containing moderate densities of aquatic plants should provide the most suitable habitat for hydrosoil macroinvertebrates.

EPIPHYTIC MACROINVERTEBRATES

Macrophyte Comparisons

Epiphytic macroinvertebrate abundance differed among host macrophytes (Table 10). In Orange Lake, *Eichhornia* supported the highest density and biomass of epiphytic macroinvertebrates followed by submersed macrophytes (*Utricularia*, *Ceratophyllum*, and *Hydrilla*). *Nuphar* and *Paspalidium* supported the lowest abundance of macroinvertebrates. In Lake Henderson, *Pistia* supported the highest biomass of macroinvertebrates, and *Utricularia* and *Eichhornia* supported a relatively high biomass of macroinvertebrates. *Utricularia* supported the highest density of macroinvertebrates, followed by *Pistia* and *Eichhornia*. Abundance was intermediate on *Ceratophyllum* and lowest on *Panicum* and *Nuphar*. A general trend for both lakes was highest abundance on floating plants, intermediate abundance on submersed plants, and lowest abundance on emergent plants.

Similar to our findings, Martin and Shireman (1976) reported a range of 577-2500 invertebrates/kg wet weight of *Hydrilla*. Andrews and Hasler (1943) found approximately 2600 invertebrates/kg wet weight of *Ceratophyllum*. Their values for four other submergent plants, *Vallisneria*, *Chara*, *Potamogeton*, and *Myriophyllum*, ranged from 150 invertebrates/kg wet weight of *Vallisneria* to 1450 invertebrates/kg wet weight of *Myriophyllum*. These numbers are also comparable to our findings. O'Hara (1968) reported a minimum value of 1986 invertebrates/kg wet weight of *Eichhornia* roots. Converting the values of Dvorak and Best (1982), under the assumptions that ash-free dry weight is 90% of a plant's dry weight and dry weight is 10% of a plant's wet weight, yields values ranging from 7,200-94,000 invertebrates/kg wet weight of submergent plants and 1260-2700 invertebrates/kg wet weight of emergent plants. The one order of magnitude difference in invertebrate density between submergent and emergent plants agrees with our findings. The lower range for submergent plants is also similar to our results, but the highest value of 94,000 is an order of magnitude higher than our and other reported values and may be questionable.

In agreement with findings by Krecker (1939), Andrews and Hasler (1943), Arner et al. (1968), and Dvorak and Best (1982), our results support a positive relationship between abundance of epiphytic macroinvertebrates and habitable surface area. Except for the high abundance of macroinvertebrates on *Utricularia* in Lake Henderson, macroinvertebrate abundance was highest on floating plants, intermediate on submergent plants and lowest on emergent plants. Krecker (1939) similarly reported that, in general, submerged, leafy types of vegetation supported higher densities of epiphytic macroinvertebrates than emergent, hard surface, non-leafy types. Arner et al. (1968) reported higher densities of invertebrates on submergent vegetation than on floating forms, but the type of floating vegetation they sampled lacked extensive root systems like those found on *Eichhornia* and *Pistia*. O'Hara (1968) observed that the length and three-dimensionality of *Eichhornia* root systems provided a greater interface area than any other floating aquatic plant. This is true in comparisons on a unit weight basis with most submergent plants as well. The stems of the emergent plants *Panicum*, *Paspalidium* and *Nuphar* lack elaborate structure, have low surface areas: biomass ratios, and thus low invertebrate abundances. Of these three emergent plants, however, *Panicum* has the highest and *Nuphar* the lowest surface area: biomass ratio. Paralleling this trend, macroinvertebrate abundance was highest on *Panicum* and lowest on *Nuphar*. Among three submergent macrophyte genera, *Utricularia* supported the highest abundance and *Hydrilla* the lowest abundance of macroinvertebrates. *Ceratophyllum* and *Utricularia* have more elaborate surface areas than *Hydrilla*, thus corroborating the invertebrate abundance-surface area relationship shown by emergent and floating plants.

iphytic macroinvertebrate abundance was positively
to periphyton abundance. From Spearman rank
tion analysis (Conover 1980) between annual means of
vertebrate density (number/kg wet weight macrophyte)
iphyton biomass (mg chlorophyll *a*/ kg wet weight
yte), r=0.60 (n=6, p=0.10) in Orange Lake and r=0.80
=0.10) in Lake Henderson.

e positive correlations between macroinvertebrate
ce and periphyton abundance suggest a trophic basis
abundance of epiphytic macroinvertebrates as
d by Rosine (1955), Cattaneo (1983) and others. In
kes, *Eichhornia* deviated from the relationship
macroinvertebrate and periphyton abundance. The
undance of macroinvertebrates on *Eichhornia* suggests
s other than food availability may influence
brate colonization of some macrophytes. The physical
ure of *Eichhornia* root masses may provide greater
tion from predation than other plants. The extremely
face area: biomass ratio of *Eichhornia*, coupled with
terlacing of its root mass may also provide more
ate for attachment and habitation than other
hytes offer. Rosine (1955) cited these reasons, as
s variations in periphyton and differing biochemical
ties of plant species as possible explanations of
abundances of macroinvertebrates on different plant
s.

he above analyses did not include macroinvertebrates
ted by the sweep sample method, because it was rarely
le to collect invertebrates from only a single
hyte species with a dip net. Linear regression
is (PROC GLM, SAS 1982) of abundance of
nvertebrates collected in sweep samples and periphyton
dencane and spatterdock stems in the maidencane,
cane-hydrilla, spatterdock, and spatterdock-hydrilla
ts (Table 27) does indicate significant positive
onships between macroinvertebrate density and

rate

10

s,

te.

periphyton biomass and between macroinvertebrate biomass and periphyton biomass.

Habitat Comparisons

Variance component analysis (PROC VARCOMP, SAS Institute 1982) was used to evaluate sources of variation in epiphytic macroinvertebrate abundance, and analysis of variance (PROC GLM, SAS Institute 1982) was used to evaluate significant effects on abundance of epiphytic macroinvertebrates. In Orange Lake, date accounted for large and significant portions of the variation in density and biomass of epiphytic macroinvertebrates collected by the plant sample method and the sweep method (Table 28). Station within habitat accounted for small, nonsignificant portions of the total variation of epiphytic macroinvertebrates, indicating the stations in each habitat were valid replicates. There were significant differences between habitats for all estimates of epiphytic macroinvertebrates except biomass by the plant sample method Plant sample data indicated high density of epiphytic macroinvertebrates in the maidencane, maidencane-hydrilla, spatterdock, and spatterdock-hydrilla habitats in Orange Lake (Table 29). Crustaceans, primarily *Hyalella*, and insects, primarily chironomid larvae, were numerically most abundant in these four habitats (Table 30). Based on sweep sampling data, high density and biomass of epiphytic macroinvertebrates were collected in the maidencane and maidencane-hydrilla habitats. High densities of crustaceans and insects were present in these habitats (Table 31). *Hyalella* and *Palaemonetes* were numerically the most abundant crustaceans. The hemipteran *Trichocorixa* and chironomid larvae were numerically abundant insects. High biomass of crustaceans, primarily *Palaemonetes*, insects, primarily hemipterans and zygopterans, and gastropods, were collected by the sweep method in the maidencane and maidencane-hydrilla habitat.

Table 28. Percent contribution of various sources to the total variance of epiphytic macroinvertebrate density (individuals/m^2, individuals/sweep) and biomass (mg dry weight/m^2, mg dry weight/sweep), October 1982 - August 1983.

		Source of Variation			
Lake	Variable	Habitat	Stations within habitat	Date	Error
Orange	individuals/m^2	11*	0	28*	61
Orange	mg/m^2	8	0	14*	78
Orange	individuals/sweep	26*	0	29*	45
Orange	mg/sweep	27*	2	38*	33
Henderson	individuals/m^2	70*	13	0	17
Henderson	mg/m^2	67*	12	0	21
Henderson	individuals/sweep	68*	0	6	26
Henderson	mg/sweep	80*	0	2	18

* Significant ($p \leq 0.05$) source of variation by analysis of variance (PROC GLM, SAS Institute 1982) of logarithm_{10} transformed data.

Table 29. Annual mean epiphytic macroinvertebrate density (individuals/m^2, individuals/sweep) and biomass (mg dry weight/m^2, mg dry weight/sweep) ± one standard deviation, October 1982 - August 1983.

		Habitat				
Lake	Varaible	Maidencane	Maidencane-hydrilla	Spatterdock	Spatterdock-hydrilla	Hydrilla
Orange	ind/m^2	5084 ± 2650 ^{a}	1574 ± 1147 ^{a,b}	4532 ± 4186 ^{a,b}	18219 ± 19192 ^{a}	471 ± 669 ^{b}
Orange	mg/m^2	1039 ± 543 ^{a}	641 ± 281 ^{a}	1400 ± 1149 ^{a}	4744 ± 4503 ^{a}	373 ± 532 ^{a}
Orange	ind/sweep	8.0 ± 2.4 ^{a}	5.3 ± 0.4 ^{a}	2.9 ± 0.6 ^{b}	2.7 ± 1.0 ^{b}	
Orange	mg/sweep	14.7 ± 9.2 ^{a}	11.3 ± 3.5 ^{a}	4.0 ± 3.3 ^{b}	2.5 ± 1.2 ^{b}	
Henderson	ind/m^2	19956 ± 11780 ^{a}		2186 ± 1698 ^{b}		
Henderson	mg/m^2	6849 ± 2498 ^{a}		637 ± 526 ^{b}		
Henderson	ind/sweep	24.6 ± 7.5 ^{a}		5.2 ± 0.9 ^{b}		
Henderson	mg/sweep	55.2 ± 16.6 ^{a}		3.8 ± 1.5 ^{b}		

[a,b] Means with the same letter, within one lake and variable, are not significantly ($p \leq 0.05$) different by Waller-Duncan test (SAS Institute 1982) of logarithm$_{10}$ transformed data.

Table 30. Annual mean epiphytic macroinvertebrate density (individuals/m^2) and biomass (mg dry weight/m^2) collected by the plant sample method, Orange Lake, October 1982 - August 1983.

	Habitat									
	Maidencane		Maidencane-hydrilla		Spatterdock		Spatterdock-hydrilla		Hydrilla	
Taxon	Density	Biomass	Density	Biomass	Density	Biomass	Density	Biomass	Density	Biomass
Platyhelminthes	3	<1	13	3	1	<1	<1	<1		
Turbellaria	3	<1	13	3	1	<1	<1	<1		
Annelida	27	15	45	21	273	96	47	27		
Oligochaeta	9	1	<1	<1	9	1	1	2		
Hirudinea	18	14	45	21	264	95	46	25		
Mollusca	75	114	73	164	193	364	660	896	97	281
Gastropoda	75	114	73	164	193	364	660	896	95	281
Pelecypoda									2	<1
Arthropoda	4977	902	1444	454	4063	940	17511	3820	374	92
Crustacea	3095	421	344	93	2492	422	13313	2771	170	52
Cladocera	1610	60			2	<1	2	<1		
Podocopa	1	<1			36	2	311	13		
Isopoda					9	1	2	2		
Amphipoda	1484	361	343	93	2420	375	12996	2754	170	52
Hyalella	1484	361	343	93	2420	375	12996	2754	170	52
Decapoda	<1	<1	1	<1	25	43	2	1		
Palaemonetes	<1	<1	1	<1	25	43	2	1		
Arachnoidea					1	<1	45	5		
Hydracarina					1	<1	45	5		
Insecta	1882	481	1100	361	1570	518	4153	1045	204	40
Ephemeroptera	1	1			6	3	5	4		
Caenis					3	2	2	1		
Baetidae					2	1				
Odonata	34	45	8	27	250	265	427	452	23	5
Ischnura	17	25			59	27	57	64	13	2
Enallagma	17	19	6	11	145	96	243	127	10	2
Libellula					36	140	1	18		
Pachydiplax							76	232		
Nanothemis							37	8		
Somatochlora					10	1	13	3		

Table 30. Continued.

Taxon	Maidencane Density	Maidencane Biomass	Maidencane-hydrilla Density	Maidencane-hydrilla Biomass	Spatterdock Density	Spatterdock Biomass	Spatterdock-hydrilla Density	Spatterdock-hydrilla Biomass	Hydrilla Density	Hydrilla Biomass
Hemiptera					30	42	21	6		
Pelocoris					8	26				
Cryphocricos					2	<1				
Trichocorixa					19	13	15	6		
Mesovelia					<1	<1	6	<1		
Neoplea					<1	<1				
Belastoma					1	3				
Lepidoptera	2	1	1	<1	<1	1			2	2
Parapoynx	2	1	1	<1	<1	1			2	2
Coleoptera			10	55	1	<1	41	5		
Galerucella			10	55						
Notomicrus					1	<1	4	<1		
Hydrocanthus					<1	<1				
Laccophilus							37	5		
Trichoptera	754	130	385	57	207	49	419	148	29	7
Oxyethira					2	<1				
Orthotrichia	724	50	313	24	35	4	49	8	20	2
Leptocerus	5	<1	<1	<1	<1	<1	3	<1		
Triaenodes			<1	<1	12	5	40	11		
Oecetis	10	7	11	3	153	39	265	120		
Ceraclea	10	70					1	<1		
Polycentropus	5	2	61	30	5	2	61	9	9	5
Diptera	1091	304	696	222	1076	156	3240	429	150	26
Chironimidae larvae	1018	278	603	183	964	140	3179	416	146	23
Chironomidae pupae	73	25	93	40	104	16	49	11	4	3
Probezzia							7	1		
Chaoborus					8	1	5	<1		

Table 31. Annual mean epiphytic macroinvertebrate density (individuals/10 sweeps) and biomass (mg dry weight/ 10 sweeps) collected by the sweep method, Orange Lake, October 1982-August 1983.

Taxon	Maidencane Density	Maidencane Biomass	Maidencane-hydrilla Density	Maidencane-hydrilla Biomass	Spatterdock Density	Spatterdock Biomass	Spatterdock-hydrilla Density	Spatterdock-hydrilla Biomass
Platyhelminthes	1	<1	1	<1	<1	<1	<1	<1
Turbellaria	1	<1	1	<1	<1	<1	<1	<1
Annelida	2	<1	3	<1	1	<1	<1	<1
Oligochaeta	2	<1	3	<1	<1	<1	<1	<1
Hirudinea			<1	<1	<1	<1	<1	<1
Mollusca	4	17	6	21	1	4	4	9
Gastropoda	4	17	6	21	1	4	4	9
Arthropoda	73	128	43	91	28	36	22	17
Crustacea	31	86	23	54	10	20	7	5
Cladocera	1	<1			4	<1	2	<1
Eucopepoda	<1	<1	<1	<1	<1	<1	<1	<1
Podocopa	<1	<1					<1	<1
Amphipoda	21	9	15	6	4	1	4	2
Hyalella	21	9	15	6	4	1	4	2
Decapoda	9	77	8	47	2	19	1	4
Palaemonetes	9	77	8	47	2	19	1	4
Arachnoidea					<1	<1		
Hydracarina					<1	<1		
Insecta	42	43	20	37	18	15	15	11
Ephemeroptera	2	1	1	<1	<1	<1	<1	<1
Caenis	1	<1			<1	<1	<1	<1
Callibaetis	1	<1	1	<1	<1	<1		
Siphloplecton					<1	<1		
Tricorythodes							<1	<1
Odonata	7	15	6	11	3	9	4	6
Ischnura	2	7	1	2	<1	<1	<1	<1
Enallagma	5	8	5	9	2	3	3	4
Telebasis	<1	<1						
Libellula					<1	5	<1	<1
Agria					<1	<1		
Pachydiplax					<1	<1	<1	1

Table 31. Continued.

Taxon	Habitat							
	Maidencane		Maidencane-hydrilla		Spatterdock		Spatterdock-hydrilla	
	Density	Biomass	Density	Biomass	Density	Biomass	Density	Biomass
Hemiptera	21	23	6	24	6	5	4	5
Cryphoricos					<1	<1		
Ranatra	1	17	1	23	<1	3	<1	3
Corixidae					<1	<1		
Trichocorixa	19	6	5	1	4	2	2	<1
Microvelia							<1	<1
Gerridae							<1	<1
Gerris					<1	<1	<1	<1
Limnogonus					<1	<1	<1	<1
Mesovelia	1	<1	<1	<1	<1	<1	2	<1
Saldidae							<1	<1
Merragata					<1	<1		
Lethocerus			<1	<1	<1	<1	<1	<1
Lepidoptera			<1	<1				
Paragyractis			<1	<1				
Parapoynx			<1	<1				
Coleoptera			<1	<1	<1	<1		
Hydrocanthus					<1	<1		
Phytonomus			<1	<1				
Phytobius					<1	<1		
Trichoptera	5	<1	4	<1	2	<1	1	<1
Oxyethira	2	<1	<1	<1	1	<1	1	<1
Orthotrichia	3	<1	3	<1	1	<1	<1	<1
Leptocerus					<1	<1	<1	<1
Oecetis	<1	<1			<1	<1		
Nectopsyche					<1	<1		
Cyrnellus			1	<1				
Diptera	7	3	3	<1	6	<1	5	<1
Chironomidae adults							<1	<1
Chironomidae larvae	6	2	3	<1	6	<1	5	<1
Chironomidae pupae	1	<1	<1	<1	<1	<1	<1	<1

In Lake Henderson, there were no significant temporal variations in epiphytic macroinvertebrate density or biomass (Table 28). Station within habitat variance was nonsignificant except for biomass estimated by the plant sample method. Habitat type accounted for significant amounts of variation for all estimates of epiphytic macroinvertebrate abundance. By both sampling methods density and biomass of epiphytic macroinvertebrates were significantly higher in the maidencane habitat (Table 29). Based on plant sample data, crustaceans, primarily *Hyalella*, and insects, primarily chironomid larvae, were the most abundant by number and weight (Table 32). High biomass of gastropods was also collected. Based on sweep samples, *Hyalella* was numerically the most abundant crustacean, but *Palaemonetes* had the highest biomass (Table 33). Abundant insects included chironomid larvae and odonate nymphs. Insects were, in general, the most abundant epiphytic macroinvertebrates in the spatterdock habitat.

Comparison of macroinvertebrate densities collected by the plant sample method and the sweep method indicated the sweep method collected larger and more motile invertebrates, such as *Palaemonetes*, odonates, and hemipterans; whereas the plant sample method collected smaller and sessile or tightly adhering invertebrates such as leeches, *Hyalella*, caddisflies, and chironomids. To achieve a more complete estimate of epiphytic macroinvertebrate abundance for further comparison of abundance by habitat we combined abundance collected by both methods as follows:

pooled density = number/m² + number/50 sweeps.

pooled biomass = number/m² + number/50 sweeps.

The results of these combinations are presented in Table 34. In Orange Lake, pooled density and pooled biomass were highest in the spatterdock-hydrilla habitat, due primarily to the abundance of *Hyalella*. In Lake Henderson, both density and biomass were higher in the maidencane habitat.

Table 32. Annual mean epiphytic macroinvertebrate density (individuals/m^2) and biomass (mg dry weight/m^2) collected by the plant sample method, Lake Henderson, October 1982-August 1983.

	Habitat			
	Maidencane		Spatterdock	
Taxon	Density	Biomass	Density	Biomass
Platyhelminthes	32	10	2	<1
Turbellaria	32	10	2	<1
Annelida	240	189	8	14
Oligochaeta	15	3		
Hirudinea	225	186	8	14
Mollusca	713	1743	69	67
Gastropoda	713	1743	69	67
Arthropoda	18970	4906	2105	555
Crustacea	15924	3211	736	106
Cladocera	7	<1	20	<1
Podocopa	156	4		
Amphipoda	15754	3093	716	105
Hyalella	15754	3093	716	105
Decapoda	7	114		
Astacidae	7	114		
Arachnoidea	7	<1	2	<1
Hydracarina	7	<1	2	<1
Insecta	3039	1694	1367	449
Ephemeroptera	46	26	18	4
Caenis	7	3	18	4
Tricorythodes	25	10		
Odonata	132	616	27	37
Enallagma	100	99	25	33
Libellula	32	517	2	3
Celithemis			<1	<1
Hemiptera			<1	<1
Ranatra			<1	<1
Trichocorixa			<1	<1
Coleoptera	16	66		
Phytonomus	16	66		
Trichoptera	365	216	126	31
Orthotrichia	262	25	110	20
Leptocerus			<1	<1
Triaenodes	22	122		
Oecetis	56	14	16	11
Ceraclea	25	55		
Diptera	2480	771	1196	377
Chironomidae larvae	2282	643	1175	373
Chironomidae pupae	121	65	11	2
Probezzia	25	3	3	<1
Hydrellia			7	2
Psychodidae	1	3		

Table 33. Annual mean epiphytic macroinvertebrate density (individuals/ 10 sweeps) and biomass (mg dry weight/10 sweeps) collected by the sweep method, Lake Henderson, October 1982-August 1983.

	Habitat			
	Maidencane		Spatterdock	
Taxon	Density	Biomass	Density	Biomass
Platyhelminthes	<1	<1	<1	<1
Turbellaria	<1	<1	<1	<1
Annelida	4	<1	1	<1
Oligochaeta	3	<1	<1	<1
Hirudinea	1	<1	<1	<1
Mollusca	37	93	6	11
Gastropoda	37	93	6	11
Pelecypoda	<1	<1		
Arthropoda	205	458	45	27
Crustacea	157	388	23	13
Cladocera	37	<1	2	<1
Eucopepoda	2	<1		
Amphipoda	85	26	20	5
Hyalella	85	26	20	5
Decapoda	33	362	1	8
Palaemonetes	32	359	1	8
Astacidae	<1	3		
Insecta	48	70	22	14
Ephemeroptera	4	2	1	<1
Caenis	3	1	1	<1
Callibaetis	1	<1		
Siphloplecton			<1	<1
Odonata	17	58	5	10
Ischnura	3	11	1	4
Enallagma	13	32	3	4
Libellula	1	15	<1	2
Pantala			<1	<1
Hemiptera	2	4	6	2
Ranatra	<1	<1	<1	<1
Trichocorixa	<1	<1	<1	<1
Mesovelia	1	<1	4	1
Neoplea			1	<1
Saldidae			<1	<1
Lethocerus	1	3	<1	<1
Coleoptera	<1	<1	<1	<1
Laccobius			<1	<1
Suphisellus			<1	<1
Pronoterus	<1	<1		
Trichoptera	6	<1	2	<1
Orthotrichia	6	<1	2	<1
Oecetis	<1	<1	<1	<1
Diptera	19	5	8	1
Chironomidae larvae	18	5	7	1
Chironomidae pupae	<1	<1		
Palpomyia			<1	<1
Probezzia			<1	<1

Table 34. Annual mean epiphytic macroinvertebrate density (individuals/m^2) and biomass (mg dry weight/m^2) estimated by combining data obtained by the plant sample method and the sweep method, October 1982-August 1983.

		Habitat							
		Maidencane		Maidencane-hydrilla		Spatterdock		Spatterdock-hydrilla	
Lake	Taxon	Density	Biomass	Density	Biomass	Density	Biomass	Density	Biomass
Orange	Turbellaria	10	2	18	4	2	<1	1	<1
	Oligochaeta	19	1	14	<1	11	<1	3	2
	Hirudinea	18	14	46	21	265	95	47	26
	Gastropoda	94	201	101	270	201	385	680	939
	Crustacea	3251	852	459	362	2543	523	13350	2798
	Insecta	2094	695	1198	547	1660	595	4225	1102
	Arachnoidea					1	<1	45	5
	Total	5486	1766	1836	1206	4683	1599	18351	4871
Henderson	Turbellaria	33	11			3	1		
	Oligochaeta	30	4			1	<1		
	Hirudinea	231	187			9	14		
	Gastropoda	898	2209			99	122		
	Pelecypoda	<1	2						
	Crustacea	16709	5154			851	169		
	Insecta	3280	2043			1478	521		
	Arachnoidea	7	<1			2	<1		
	Total	21188	9610			2443	827		

Epiphytic macroinvertebrates were more abundant in habitats with high plant biomass. This was due in part, to the fact that macroinvertebrate abundance determined by the plant sample method was a function of plant biomass. However, other researchers have shown the importance of macrophytes as a life substrate (Rosine 1955, Krull 1970, Soska 1975). Because substrate is directly related to plant biomass, epiphytic macroinvertebrate abundance would be, expectedly, positively related to plant biomass. In addition, there were differences in abundant taxa between habitats and lakes. In Orange Lake, the spatterdock-hydrilla habitat supported the highest density and biomass of epiphytic macroinvertebrates when the plant sample method and combined plant-sample-sweep-sample method were considered. The maidencane and maidencane-hydrilla habitats, however, supported higher biomass of epiphytic macroinvertebrates when the sweep method was considered alone. This descrepancy resulted from the greater abundance of large insects and *Palaemonetes* in the habitats containing maidencane. Density and biomass of epiphytic macroinvertebrates in the Lake Henderson maidencane habitat were higher than in the Orange Lake maidencane habitat. Stem density and biomass of maidencane were also higher in Lake Henderson. These results suggest that maidencane, particularly in high density, was a more desirable habitat for larger epiphytic macroinvertebrates than is spatterdock. This is further supported by Dvorak and Best (1982) who reported the highest invertebrate biomass per m² was found in macrophytes stands of high density.

It is apparent that many factors govern the distribution and abundance of epiphytic macroinvertebrates. Macrophyte morphology is a major determinant of invertebrate colonization. A higher surface area:biomass ratio provides a more extensive substrate for invertebrate attachment and for the growth of periphyton. In addition, morphology of the plant can very likely be a significant determinant of vulnerability to predation.

Macrophyte community structure can influence the abundance of epiphytic macroinvertebrates found in any one habitat. In general, a greater abundance and diversity of macrophytes leads to a greater abundance and diversity of epiphytic macroinvertebrates (Rosine 1955). A desirable community structure would be one containing dense stands of emergent vegetation ,such as *Panicum*, interspersed with small dense patches of submergent and floating vegetation. Dense emergent vegetation provides habitat for larger invertebrates, while submergent and floating plants supports smaller animals. The floating vegetation also tends to stabilize and shelter the environment, a factor Voigts (1976) suggested influenced invertebrate distribution.

FISH

Abundance of Sport fish (Electroshocking)

Orange Lake

Few small (<300 mm TL) chain pickerel were collected (Table 35). Catch/hour (C/f) was highest in the maidencane, maidencane-hydrilla, and spatterdock-hydrilla habitats in October, December, and February. Large ($\geq$ 300 mm) chain pickerel were most abundant in the maidencane and spatterdock-hydrilla habitats in October and December.

Mean annual C/f of small (<150 mm TL) bluegill was highest in the spatterdock-hydrilla habitat and similar in other habitats in Orange Lake. Small bluegill were abundant in vegetated habitats in October and April. The high average C/f in spatterdock-hydrilla was strongly affected by a very high C/f in this habitat in April. Large ($\geq$ 150 mm TL) bluegill were most abundant in the maidencane and maidencane-hydrilla habitats. High C/f were recorded in February and April.

Few redear sunfish were collected by electroshocking. Small (<150 mm TL) redear sunfish were most abundant in the spatterdock-hydrilla and hydrilla habitats and were most frequently collected in the fall and winter. Large ($\geq$ 150 mm TL) redear sunfish were most abundant in the maidencane and hydrilla habitats in the April sample.

Mean annual C/f of small (<300 mm) largemouth bass was highest in the spatterdock-hydrilla and hydrilla habitats. Catch of small largemouth bass was relatively high throughout the year in the spatterdock-hydrilla habitat. Small largemouth bass were most abundant in the other habitats in October and December. Annual average C/f of large ($\geq$ 300 mm TL) largemouth bass were highest in the spatterdock-hydrilla habitat and moderate in the maidencane and maidencane-hydrilla habitats. The high C/f in

Table 35. Mean catch per hour of sport fish by electrofishing in Orange Lake, October 1982–August 1983.

Date	Species	Size (TL,mm)	Habitat Maidencane	Maidencane-hydrilla	Spatterock	Spatterdock-hydrilla	Hydrilla	Average
Oct	Chain pickerel	<300	2.0	1.0	0.0	2.5	0.0	1.1
	Chain pickerel	≥300	12.0	3.5	2.9	8.1	0.0	5.3
	Bluegill	<150	17.0	6.0	4.2	10.0	11.7	9.8
	Bluegill	≥150	3.3	0.0	1.2	0.0	1.3	1.2
	Redear sunfish	<150	0.0	0.0	0.0	0.0	1.2	0.2
	Redear sunfish	≥150	0.0	0.0	0.0	0.0	0.6	0.1
	Largemouth bass	<300	20.0	10.0	3.5	10.0	15.2	11.7
	Largemouth bass	≥300	3.0	2.0	1.2	0.7	1.3	1.7
Dec	Chain pickerel	<300	2.1	0.9	0.7	0.7	0.0	0.9
	Chain pickerel	≥300	13.7	0.8	2.0	8.8	5.2	6.1
	Bluegill	<150	1.1	0.7	4.0	5.6	5.2	3.3
	Bluegill	≥150	0.7	0.0	4.7	2.4	0.7	1.7
	Redear sunfish	<150	0.0	0.0	0.7	4.8	0.7	1.2
	Redear sunfish	≥150	0.0	0.0	0.0	0.0	2.0	0.4
	Largemouth bass	<300	5.3	1.9	1.3	8.8	27.8	9.0
	Largemouth bass	≥300	0.0	0.8	1.3	0.0	0.9	0.6
Feb	Chain pickerel	<300	0.0	0.7	0.0	1.3	0.0	0.4
	Chain pickerel	≥300	5.6	2.1	2.0	4.8	2.0	3.3
	Bluegill	<150	2.2	1.4	1.3	2.7	1.3	1.8
	Bluegill	≥150	22.2	31.0	1.3	6.9	6.0	13.5
	Redear sunfish	<150	1.1	1.0	0.0	0.0	1.3	0.7
	Redear sunfish	≥150	2.2	0.0	0.0	0.0	2.7	1.0
	Largemouth bass	<300	1.1	2.0	0.7	5.2	3.3	2.5
	Largemouth bass	≥300	12.2	6.0	5.3	18.6	2.7	9.0

Table 35. Continued.

Date	Species	Size (TL,mm)	Habitat Maidencane	Maidencane-hydrilla	Spatterdock	Spatterdock-hydrilla	Hydrilla	Average
Apr	Chain pickerel	<300	0.0	0.0	0.0	0.0	0.0	0.0
	Chain pickerel	≥300	1.1	0.0	0.7	1.3	0.0	0.6
	Bluegill	<150	0.0	0.0	8.7	27.1	0.0	7.2
	Bluegill	≥150	12.0	10.0	4.0	10.6	0.7	7.5
	Redear sunfish	<150	0.0	0.0	0.0	0.0	0.0	0.0
	Redear sunfish	≥150	1.1	0.0	0.0	0.6	0.0	0.3
	Largemouth bass	<300	0.0	1.3	2.0	10.6	0.0	2.8
	Largemouth bass	≥300	4.0	10.0	0.0	20.0	0.0	6.8
Jun	Chain pickerel	<300	0.0	0.0	0.0	0.0	0.0	0.0
	Chain pickerel	≥300	2.5	0.0	0.7	2.0	0.0	1.0
	Bluegill	<150	0.0	1.1	3.3	9.3	0.7	2.9
	Bluegill	≥150	3.3	0.0	1.3	0.7	0.0	1.1
	Redear sunfish	<150	0.0	0.9	0.0	0.0	0.0	0.2
	Redear sunfish	≥150	0.0	0.0	0.0	0.0	0.0	0.0
	Largemouth bass	<300	6.7	0.0	7.3	9.3	0.0	4.7
	Largemouth bass	≥300	2.5	2.2	2.0	4.0	0.7	2.3
Aug	Chain pickerel	<300	0.0	0.0	0.0	0.0	0.0	0.0
	Chain pickerel	≥300	1.2	2.9	1.3	1.3	2.0	1.5
	Bluegill	<150	0.0	3.6	0.0	1.3	0.7	1.1
	Bluegill	≥150	6.2	3.6	2.7	0.9	0.7	2.8
	Redear sunfish	<150	0.0	0.0	0.0	0.0	0.0	0.0
	Redear sunfish	≥150	0.0	0.0	0.0	0.0	0.0	0.0
	Largemouth bass	<300	0.0	1.8	5.3	7.3	3.3	3.5
	Largemouth bass	≥300	4.7	4.7	0.7	4.7	2.0	3.4

Table 35. Continued.

Date	Species	Size (TL,mm)	Habitat: Maidencane	Maidencane-hydrilla	Spatterdock	Spatterdock-hydrilla	Hydrilla	Average
Annual Average								
	Chain pickerel	<300	0.7	0.4	0.1	0.8	0.0	0.4
	Chain pickerel	≥300	6.0	1.6	1.6	4.4	1.2	3.0
	Bluegill	<150	3.4	2.1	3.6	9.3	3.3	4.4
	Bluegill	≥150	8.0	7.4	2.5	3.6	1.6	4.6
	Redear sunfish	<150	0.2	0.3	0.1	0.8	0.5	0.4
	Redear sunfish	≥150	0.6	0.0	0.0	0.1	0.9	0.3
	Largemouth bass	<300	5.5	2.8	3.4	8.5	8.3	5.7
	Largemouth bass	≥300	4.4	4.3	1.8	8.0	1.3	4.0

spatterdock-hydrilla was largely affected by very high C/f in February and April. C/f in the maidencane and maidencane-hydrilla habitats was relatively consistent throughout the year.

Lake Henderson

No small (<300 mm TL) chain pickerel were collected by electrofishing in Lake Henderson. Large chain pickerel were collected in low abundance in the maidencane and spatterdock habitats throughout the year except in August (Table 36).

C/f of small bluegill was highest in the maidencane habitat and no small bluegill were collected in open water. C/f of small bluegill was highest in April. Large bluegill were most abundant in the maidencane habitat. Although large bluegill were consistently collected in the maidencane, highest abundance was recorded in June and August. Moderate numbers of large bluegills were collected in the spatterdock habitat in all sampling trips except February.

Of the few redear sunfish collected, both small and large redear were most abundant in the maidencane habitat. In June, C/f of redear sunfish was higher in the spatterdock habitat than in the maidencane habitat.

Large and small largemouth bass were most abundant in the maidencane habitat and least abundant in the open water habitat. C/f of small largemouth bass was highest in the maidencane habitat in April. High C/f of largemouth bass occurred in April and June. C/f of small and large largemouth bass was higher in the spatterdock than the maidencane habitat in December.

Table 36 . Mean catch per hour of sport fish by electrofishing in Lake Henderson, October 1982–August 1983.

Date	Species	Size (TL,mm)	Habitat Maidencane	Spatterdock	Open Water	Average
Oct	Chain pickerel	<300	2.0	0.0	0.0	0.0
	Chain pickerel	≥300	0.0	1.9	0.0	1.3
	Bluegill	≤150	3.0	1.9	0.0	1.6
	Bluegill	≥150	12.6	5.2	0.0	5.9
	Redear sunfish	≤150	2.2	0.0	0.8	1.0
	Redear sunfish	≥150	2.2	1.3	0.0	1.2
	Largemouth bass	≤300	6.7	7.1	1.6	5.1
	Largemouth bass	≥300	5.9	10.3	4.0	6.7
Dec	Chain pickerel	<300	0.0	0.0	0.0	0.0
	Chain pickerel	≥300	1.7	1.7	0.0	1.1
	Bluegill	≤150	1.4	6.9	0.0	2.8
	Bluegill	≥150	4.8	6.9	0.7	4.1
	Redear sunfish	≤150	2.1	0.0	0.0	0.7
	Redear sunfish	≥150	1.4	1.1	0.0	0.8
	Largemouth bass	≤300	3.4	4.6	0.7	2.9
	Largemouth bass	≥300	6.9	7.4	0.7	5.0
Feb	Chain pickerel	<300	0.0	0.0	0.0	0.0
	Chain pickerel	≥300	1.8	0.0	0.0	0.6
	Bluegill	≤150	0.0	0.0	0.0	0.0
	Bluegill	≥150	5.5	0.0	2.5	2.7
	Redear sunfish	≤150	1.0	0.0	0.0	0.3
	Redear sunfish	≥150	0.9	0.6	0.0	0.5
	Largemouth bass	≤300	4.5	1.9	0.0	2.1
	Largemouth bass	≥300	3.6	3.8	1.9	3.1

Table 36. Continued.

Date	Species	Size (TL,mm)	Habitat Maidencane	Spatterdock	Open Water	Average
Apr	Chain pickerel	<300	0.0	0.0	0.0	0.0
	Chain pickerel	≥300	1.0	0.7	0.0	0.6
	Bluegill	≤150	9.6	2.0	0.0	3.9
	Bluegill	≥150	3.2	2.0	0.0	1.7
	Redear sunfish	≤150	0.0	0.0	0.0	0.0
	Redear sunfish	≥150	4.0	0.0	0.0	1.3
	Largemouth bass	≤300	24.0	8.7	1.6	11.4
	Largemouth bass	≥300	12.8	1.3	0.7	4.9
June	Chain pickerel	<300	0.0	0.0	0.0	0.0
	Chain pickerel	≥300	1.3	2.0	0.0	1.1
	Bluegill	≤150	7.4	0.7	0.0	2.7
	Bluegill	≥150	19.3	4.7	0.7	8.2
	Redear sunfish	≤150	0.0	0.7	0.0	0.2
	Redear sunfish	≥150	0.0	0.7	0.0	0.2
	Largemouth bass	≤300	8.9	7.3	0.0	5.4
	Largemouth bass	≥300	12.6	3.3	2.4	6.1
Aug	Chain pickerel	<300	0.0	0.0	0.0	0.0
	Chain pickerel	≥300	0.0	0.0	0.0	0.0
	Bluegill	≤150	2.0	2.0	0.0	1.3
	Bluegill	≥150	20.7	2.8	0.0	7.8
	Redear sunfish	≤150	0.0	0.0	0.0	0.0
	Redear sunfish	≥150	0.7	0.0	0.0	0.2
	Largemouth bass	≤300	5.0	4.0	0.0	3.0
	Largemouth bass	≥300	6.4	4.8	0.0	3.7

Table 36. Continued.

Date	Species	Size (TL,mm)	Habitat Maidencane	Habitat Spatterdock	Habitat Open Water	Average
Annual Average						
	Chain pickerel	<300	0.0	0.0	0.0	0.0
	Chain pickerel	>300	1.3	1.0	0.0	0.8
	Bluegill	<150	3.9	2.2	0.0	2.0
	Bluegill	≥150	10.2	3.6	0.6	5.1
	Redear sunfish	<150	0.9	0.1	0.1	0.4
	Redear sunfish	≥150	1.5	0.6	0.0	0.7
	Largemouth bass	<300	8.8	5.6	0.6	5.0
	Largemouth bass	≥300	8.0	5.2	1.6	5.0

Fish Communities (Blocknet-Rotenone)

Orange Lake

The open water habitat had the lowest biomass, density and diversity of fish (Table 37). Lower density and diversity but higher biomass were collected in the fall than the spring (Tables 38, 39). High biomass of gizzard shad and bluegill were collected. Gizzard shad were all large individuals and bluegills were primarily fish >160 mm TL (Table 40). Both species were abundant in fall and spring samples. High biomass of Florida gar were present in the fall and high biomass of large black crappie were present in the spring. Numerically abundant species included bluespotted sunfish and bluegill. Both species were present at higher densities in the spring. Species not collected from open water in the fall but present in the spring included bowfin, chain pickerel, golden shiner, taillight shiner, bluefin killifish, least killifish, brook silverside, bluespotted sunfish, and swamp darter. Florida gar and largemouth bass were collected only in the fall.

Biomass of harvestable sport fish was relatively low in the open water habitat (Table 37). Harvestable sport fish were 34% of the total fish biomass present and included 5.2 kg/ha bluegill, 0.8 kg/ha redear sunfish, and 2.8 kg/ha black crappie. Percent harvestable sport fish was higher in the fall than the spring (Tables 38, 39).

Forage fish:piscivorous fish ratios (F/P) were high for 40-119 mm piscivores (F/P 40) and low for larger predators in the open water habitat (Table 41). The high ratio for 40-119 mm piscivores resulted from 10 gm of chain pickerel as the only piscivore. The low F/P 320 was due largely to the biomass of Florida gar.

The maidencane habitat had the lowest biomass and density of fish of the vegetated habitats. Biomass and density were higher in the fall than the spring. Golden shiners and bluegills were the dominant species by weight.

Table 37. Mean biomass (gm/ha) and density (no/ha) of fish collected by blocknet-rotenone in Orange Lake, 1982-1983.

Species		Habitat: Maidencane	Maidencane-hydrilla	Spatterdock	Spatterdock-hydrilla	Hydrilla	Open water	Lake Average
Florida gar	gm/ha	1700	725	7268	1869	7517	3315	3732
	no/ha	2	4	12	4	10	2	6
Bowfin	gm/ha			3446	3744	5271	1550	2335
	no/ha			2	4	2	2	2
Gizzard shad	gm/ha	1671	7518	1123		5415	7802	3921
	no/ha	4	21	2		10	15	9
Chain pickerel	gm/ha	8074	10422	8934	13609	4930	24	7661
	no/ha	123	162	92	194	279	23	145
Golden shiner	gm/ha	16371	13569	15336	19178	8010	1785	12375
	no/ha	1708	2002	2821	2752	967	40	1715
Taillight shiner	gm/ha	3	15		25	10	58	19
	no/ha	2	10		17	15	52	16
Lake chubsucker	gm/ha	4369	1111	5798	6566			2974
	no/ha	12	8	31	50			17
Brown bullhead	gm/ha		14					2
	no/ha		2					<1
Golden topminnow	gm/ha	40	1047	9	314	184		266
	no/ha	100	1850	19	417	377		461
Flagfish	gm/ha		22		37	5		11
	no/ha		42		19	4		11
Bluefin killifish	gm/ha	1258	196	416	962	575		568
	no/ha	2152	1465	1090	2481	4019		1868

Table 37. Continued.

Species		Habitat: Maidencane	Maidencane-hydrilla	Spatterdock	Spatterdock-hydrilla	Hydrilla	Open water	Lake Average
Mosquitofish	gm/ha	34	326	28	122	74		97
	no/ha	162	1583	148	479	340		452
Least killifish	gm/ha	1	7	1	2	2	1	2
	no/ha	4	60	15	17	3	2	17
Sailfin molly	gm/ha		22		2	3		5
	no/ha		44		2	8		9
Brook silverside	gm/ha	352	23	16	24	9	60	81
	no/ha	435	15	29	23	10	21	89
Banded pygmy sunfish	gm/ha	4		4	5			2
	no/ha	25		8	21			9
Bluespotted sunfish	gm/ha	682	2762	1423	8355	1193	86	2408
	no/ha	862	4217	1190	11912	2400	171	3459
Warmouth	gm/ha	295	4416	2981	5815	2339		2641
	no/ha	79	567	233	1035	250		361
Bluegill	gm/ha	12088	13456	14360	20177	19158	6387	14271
	no/ha	1188	3225	1217	2271	3406	408	1953
Dollar sunfish	gm/ha		14	96	215	12		56
	no/ha		6	25	71	4		18
Redear sunfish	gm/ha	772	2552	1551	1664	12845	917	3383
	no/ha	119	94	90	377	117	12	135
Largemouth bass	gm/ha	3612	2601	7557	24085	3042	892	6965
	no/ha	38	31	23	90	17	2	33

Table 37. Continued.

Species		Maidencane	Maidencane-hydrilla	Spatterdock	Spatterdock-hydrilla	Hydrilla	Open water	Lake Average
		Habitat						
Black crappie	gm/ha	2045	2619	3090	2187	7319	2835	3349
	no/ha	40	98	46	67	73	10	56
Swamp darter	gm/ha	16	9	18	12	15	5	13
	no/ha	44	29	48	29	56	21	38
Total	gm/ha	53333	63446	73455	108969	77928	25717	67139
	no/ha	7099	15535	7141	22332	12367	781	10879
Total number species		19	22	20	22	21	14	20
Harvestable sport fish	gm/ha	9566	14702	25340	49493	37082	8824	24168
Percent harvestable sportfish by weight		18	23	35	45	48	34	34

Table 38. Mean biomass (gm/ha) and density (no/ha) of fish collected by blocknet-rotenone in Orange Lake, Fall 1982.

Species		Maidencane	Maidencane-hydrilla	Spatterdock	Spatterdock-hydrilla	Hydrilla	Open Water	Lake Average
		Habitat						
Florida gar	gm/ha	3400	1450	13186		15033	6629	6616
	no/ha	4	8	21		21	4	10
Bowfin	gm/ha			6892	11487	10542		4820
	no/ha			4	8	4		3
Gizzard shad	gm/ha						7813	1302
	no/ha						17	3
Chain pickerel	gm/ha	16050	20650	10033	23537	2108		12063
	no/ha	42	46	37	63	8		33
Golden shiner	gm/ha	13367	8896	11329	17139	4525		9209
	no/ha	1687	2217	1479	3204	1346		1655
Taillight shiner	gm/ha	6	30		49	20		18
	no/ha	4	21		33	29		15
Lake chubsucker	gm/ha	3896	197	9750	4155			3000
	no/ha	13	12	33	54			19
Brown bullhead	gm/ha							
	no/ha							
Golden topminnow	gm/ha	71	2093	10	606	364		524
	no/ha	196	3700	13	783	750		907
Flagfish	gm/ha		44		74	10		21
	no/ha		83		37	8		21
Bluefin killifish	gm/ha	2515	226	232	892	205		678
	no/ha	4296	1937	304	3563	1129		1871
Mosquitofish	gm/ha	68	652	43	219	143		187
	no/ha	325	3167	221	833	671		869
Least killifish	gm/ha	1	10		<1	4		3
	no/ha	8	79		4	46		23

Table 38. Continued.

Species		Habitat						
		Maidencane	Maidencane-hydrilla	Spatterdock	Spatterdock-hydrilla	Hydrilla	Open Water	Lake Average
Sailfin molly	gm/ha		43		4	7		9
	no/ha		87		4	17		18
Brook silverside	gm/ha	628	5		35	7		112
	no/ha	842	12		33	17		151
Banded pygmy sunfish	gm/ha	9		1	5			2
	no/ha	50		4	25			13
Bluespotted sunfish	gm/ha	892	550	218	4057	828		1091
	no/ha	1425	1150	221	4783	1771		1558
Warmouth	gm/ha	204	4515	3844	5016	3430		2835
	no/ha	146	954	254	1508	346		535
Bluegill	gm/ha	16178	14818	11304	5861	22940	9141	13374
	no/ha	1854	5529	704	1583	4300	71	2340
Dollar sunfish	gm/ha		9	16	199	23		41
	no/ha		4	4	75	8		15
Redear sunfish	gm/ha	1271	3337	907	1308	19949	1258	4672
	no/ha	221	158	96	437	179	4	183
Largemouth bass	gm/ha	634	1768	1896	2562	5646	1783	2381
	no/ha	33	42	17	67	17	4	30
Black crappie	gm/ha	2752	3762	3956	298	7067	1958	3299
	no/ha	58	187	75	83	121	12	89
Swamp darter	gm/ha	32	2	6	18	5		11
	no/ha	83	8	17	42	12		27
Total	gm/ha	61974	63057	73622	77522	92856	28582	66269
	no/ha	11287	19401	3504	17222	10800	112	10388
Total number species		18	20	17	21	20	6	
Harvestable sportfish	gm/ha	26795	34294	19104	25578	46268	11192	27205
Percent harvestable sportfish		43	54	26	33	50	39	41

Table 39. Mean biomass (gm/ha) and density (no/ha) of fish collected by blocknet-rotenone in Orange Lake, Spring 1983.

Species		Habitat						
		Maidencane	Maidencane-hydrilla	Spatterdock	Spatterdock-hydrilla	Hydrilla	Open Water	Lake Average
Florida gar	gm/ha			1350	3737			848
	no/ha			4	8			2
Bowfin	gm/ha						3100	517
	no/ha						4	1
Gizzard shad	gm/ha	3342	15035	2246		10829	7292	6541
	no/ha	8	42	4		21	13	15
Chain pickerel	gm/ha	98	194	7834	3681	7751	48	3268
	no/ha	204	279	146	325	550	46	258
Golden shiner	gm/ha	19374	18243	19343	21217	11496	3571	15541
	no/ha	1729	1787	4162	2300	587	79	1774
Taillight shiner	gm/ha						115	19
	no/ha						104	17
Lake chubsucker	gm/ha	4842	2025	1845	8976			2948
	no/ha	12	4	29	46			15
Brown bullhead	gm/ha		28					5
	no/ha		4					1
Golden topminnow	gm/ha	9		9	21	3		7
	no/ha	4		21	50	4		13
Flagfish	gm/ha							
	no/ha							
Bluefin killifish	gm/ha	2	165	600	1033	944	16	460
	no/ha	8	992	1875	1400	6908	104	1881
Mosquitofish	gm/ha			13	26	4		7
	no/ha			75	125	8		35
Least killifish	gm/ha		3	2	3		<1	1
	no/ha		42	29	29		4	17
Sailfin molly	gm/ha							
	no/ha							

Table 39. Continued.

Species		Maidencane	Maidencane-hydrilla	Spatterdock	Spatterdock-hydrilla	Hydrilla	Open Water	Lake Average
		Habitat						
Brook silverside	gm/ha	76	42	33	12	12	119	49
	no/ha	29	17	58	13	4	42	27
Banded pygmy sunfish	gm/ha			7	4			2
	no/ha			12	17			5
Bluespotted sunfish	gm/ha	365	4974	2627	12653	1559	171	3725
	no/ha	300	7283	2158	19042	3029	342	5359
Warmouth	gm/ha	386	4316	2117	6614	1247		2447
	no/ha	12	179	212	563	154		187
Bluegill	gm/ha	7999	12094	17416	34493	15376	3632	15168
	no/ha	521	921	1729	2958	2513	746	1565
Dollar sunfish	gm/ha		19	177	230			71
	no/ha		8	46	67			20
Redear sunfish	gm/ha	272	1767	2194	2020	5740	575	2095
	no/ha	17	29	83	317	54	21	87
Largemouth bass	gm/ha	6589	3433	13218	45608	438		11548
	no/ha	42	21	29	112	17		37
Black crappie	gm/ha	1338	1476	2225	4076	7571	3713	3400
	no/ha	21	8	17	50	25	8	21
Swamp darter	gm/ha	1	16	29	6	24	9	14
	no/ha	4	50	79	17	100	42	49
Total	gm/ha	44693	63830	73285	144410	62994	22861	68680
	no/ha	2911	11666	10768	27439	13974	1555	11386
Total number species		14	16	19	18	14	13	
Harvestable sportfish	gm/ha	7855	15762	31578	73410	28850	6458	27319
Percent harvestable sportfish		18	25	43	51	46	28	35

Table 40. Annual mean biomass (gm/ha) and density (no/ha) of fish collected by blocknet-rotenone in the open water habitat, Orange Lake, 1982-1983.

Species		Size Class (mm TL) 0-39	40-79	80-119	120-159	160-199	200-239	240-279	280-319	>320
Florida gar	gm/ha									3315
	no/ha									2
Bowfin	gm/ha									1550
	no/ha									2
Gizzard shad	gm/ha									7208
	no/ha									15
Chain pickerel	gm/ha	1	14	10						
	no/ha	2	17	4						
Golden shiner	gm/ha			92	285	498	419		492	
	no/ha			12	10	10	4		2	
Taillight shiner	gm/ha	1	58							
	no/ha	2	50							
Bluefin killifish	gm/ha	8								
	no/ha	52								
Least killifish	gm/ha	1								
	no/ha	2								
Brook silverside	gm/ha	1	3	56						
	no/ha	2	2	17						
Bluespotted sunfish	gm/ha	68	18							
	no/ha	156	15							
Bluegill	gm/ha	42	442	179	559	1505	3058	602		
	no/ha	92	265	12	10	12	15	2		
Redear	gm/ha		6		86	195		629		
	no/ha		4		4	2		2		

Table 40. Continued.

Species		Size Class (mm TL) 0-39	40-79	80-119	120-159	160-199	200-239	240-279	280-319	>320
Largemouth bass	gm/ha								892	
	no/ha								2	
Black crappie	gm/ha						550	429	808	1048
	no/ha						4	2	2	2
Swamp darter	gm/ha	4	1							
	no/ha	19	2							

Table 41. Mean annual forage fish - piscivorous fish (F/P) ratios for Orange Lake and Lake Henderson, October 1982 - August 1983.

Lake	Habitat	F/P 40	F/P 120	F/P 200	F/P 320
Orange	Maidencane	3.25	5.80	1.42	1.41
	Maidencane-hydrilla	2.74	3.76	1.92	1.70
	Spatterdock	0.81	2.61	1.81	0.82
	Spatterdock-hydrilla	1.71	6.94	3.17	0.70
	Hydrilla	2.77	4.79	1.04	0.72
	Open water	5.08		0.25	0.17
	Lake Average	2.05	4.78	1.70	0.87
Henderson	Maidencane	0.30	1.21	0.47	0.31
	Spatterdock	0.13	1.39	0.38	0.14
	Open water	0.35	1.84	0.38	0.80
	Lake Average	0.29	1.27	0.45	0.32

High biomass of both species were collected in fall and spring. High biomass of chain pickerel was collected in the fall. Bluefin killifish was the most abundant species by number. High densities of this species and bluegills, golden shiners, and bluespotted sunfish were collected in the fall. Except for largemouth bass and gizzard shad, all species were less abundant in the spring. Only golden shiners were collected at high densities in the maidencane habitat in the spring. Florida gar, taillight shiners, mosquitofish, least killifish, and banded pygmy sunfish were collected in the fall. Other notable temporal differences include the abundance of young-of-the-year (YOY) chain pickerel in the spring and greater abundance of small redear sunfish and black crappie in the fall.

Harvestable sport fish were 18% of the total fish biomass in the maidencane habitat. The low biomass of harvestable fish included 7.6 kg/ha bluegill, 0.3 kg/ha redear sunfish and 1.6 kg/ha black crappie (Table 42). The moderately abundant largemouth bass were all YOY and juvenile fish. Biomass and percent biomass of harvestable sport fish were much higher in fall than spring, largely resulting from the abundance of chain pickerel in the fall.

F/P ratios were high for all piscivore size classes due to low piscivore biomass. Although piscivore biomass was higher in the fall, F/P ratios were lower in the spring (Table 43) due to lower abundance of small forage fish.

Fish biomass, density, and diversity in the maidencane-hydrilla habitat were higher than in the maidencane habitat. Density was higher in fall than spring; biomass was similar in the two periods. Golden shiners and bluegills were the most abundant species by weight. The biomass of golden shiners was predominantly 80-119 mm fish; bluegills were predominantly <80 mm fish (Table 44). Relatively high biomass of chain pickerel and gizzard shad were also present. Bluegills and chain pickerel were abundant by weight in the fall. Golden shiners, gizzard

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Table 42. Annual mean biomass (gm/ha) and density (no/ha) of fish collected by blocknet-rotenone in the maidencane habitat, Orange Lake, 1982-1983.

Species		Size Class (mm TL)								
		0-39	40-79	80-119	120-159	160-199	200-239	240-279	280-310	>320
Florida gar	gm/ha									1700
	no/ha									2
Gizzard shad	gm/ha									1671
	no/ha									4
Chain pickerel	gm/ha	3	39	7					267	7758
	no/ha	17	83	2					2	19
Golden shiner	gm/ha		880	7016	2980	805	511	1367	2121	692
	no/ha		319	169	173	19	6	10	10	2
Taillight shiner	gm/ha		3							
	no/ha		2							
Lake chubsucker	gm/ha		36					1383		2950
	no/ha		2					6		4
Golden topminnow	gm/ha	19	21							
	no/ha	79	21							
Bluefin killifish	gm/ha	1246	12							
	no/ha	2129	23							
Mosquitofish	gm/ha	33	1							
	no/ha	160	2							
Least killifish	gm/ha	1								
	no/ha	4								
Brook silverside	gm/ha	6	304	42						
	no/ha	33	385	17						
Banded pygmy sunfish	gm/ha	4								
	no/ha	25								

Table 42. Continued.

Species		Size Class (mm TL) 0-39	40-79	80-119	120-159	160-199	200-239	240-279	280-319	>320
Bluespotted sunfish	gm/ha	246	383							
	no/ha	575	288							
Warmouth	gm/ha	17	72	30	176					
	no/ha	40	35	2	2					
Bluegill	gm/ha	58	1828	1790	822	1838	4528	1225		
	no/ha	108	902	112	23	17	21	4		
Redear sunfish	gm/ha	8	250	70	124	321				
	no/ha	12	94	6	4	2				
Largemouth bass	gm/ha	100	175	176	100	254	1538	1269		
	no/ha	8	8	6	2	2	6	4		
Black crappie	gm/ha	18	65	27		281			631	1023
	no/ha	4	23	4		4			2	2
Swamp darter	gm/ha	2	14							
	no/ha	6	38							

Table 43. Forage fish-piscivorous fish ratios (F/P) for Fall (November-December) 1982 and Spring (March-April) 1983 samples in Orange Lake and Lake Henderson.

Date	Lake	Habitat	F/P 40	F/P 120	F/P 200	F/P 320
Fall 82	Orange	Maidencane	4.02	13.84	18.52	0.85
		Maidencane-hydrilla	1.83	3.68	3.14	0.92
		Spatterdock	0.32	1.18	0.83	0.36
		Spatterdock-hydrilla	0.86	8.35	9.01	0.69
		Hydrilla	2.10	4.50	1.07	0.52
		Open water	-	-	0	0.01
		Lake average	1.42	4.47	2.15	0.61
Spring 83	Orange	Maidencane	0.56	1.87	0.19	-
		Maidencane-hydrilla	5.09	3.92	1.11	-
		Spatterdock	1.76	5.00	3.42	1.48
		Spatterdock-hydrilla	3.32	6.19	2.17	0.71
		Hydrilla	3.77	5.30	0.99	1.55
		Open water	5.10	-	0.82	0.38
		Lake average	3.31	5.18	1.38	1.32
Fall 82	Henderson	Maidencane	0.36	1.91	0.57	0.39
		Spatterdock	0.13	2.49	0.33	0.14
		Open water	0.17	2.12	0.43	1.02
		Lake average	0.33	1.96	0.52	0.39
Spring 83	Henderson	Maidencane	1.07	2.13	1.27	0.46
		Spatterdock	0.12	0.71	0.56	0.15
		Open water	-	1.37	0.29	0.36
		Lake average	0.16	0.51	0.29	0.22

Table 44. Annual mean biomass (gm/ha) and density (no/ha) of fish collected by blocknet-rotenone in the maidencane-hydrilla habitat, Orange Lake, 1982-1983.

Species		0-39	40-79	80-119	120-159	160-199	200-239	240-279	280-319	>320
Florida gar	gm/ha								179	546
	no/ha								2	2
Gizzard shad	gm/ha			32			865			6620
	no/ha			2			2			17
Chain pickerel	gm/ha	2	71	5	18					10325
	no/ha	17	119	2	2					23
Golden shiner	gm/ha		1231	6015	1929	174	1608	1433	619	560
	no/ha		527	1242	194	6	19	10	2	2
Taillight shiner	gm/ha		15							
	no/ha		10							
Lake chubsucker	gm/ha				50	49				1012
	no/ha				4	2				2
Brown bullhead	gm/ha		14							
	no/ha		2							
Golden topminnow	gm/ha	498	548							
	no/ha	1338	512							
Flagfish	gm/ha	22								
	no/ha	42								
Bluegin killifish	gm/ha	195	1							
	no/ha	1462	2							
Mosquitofish	gm/ha	300	26							
	no/ha	1535	48							
Least killifish	gm/ha	7								
	no/ha	60								
Sailfin molly	gm/ha	13	8							
	no/ha	38	6							
Brook silverside	gm/ha		10	14						
	no/ha		10	4						

Table 44. Continued.

Species		Size Class (mm TL)								
		0-39	40-79	80-119	120-159	160-199	200-239	240-279	280-319	>320
Bluespotted sunfish	gm/ha	1798	964							
	no/ha	3481	735							
Warmouth	gm/ha	120	435	266	569	1927	1098			
	no/ha	240	281	12	12	17	4			
Bluegill	gm/ha	430	3690	903	830	1294	4885	1423		
	no/ha	815	2296	62	17	12	19	4		
Dollar sunfish	gm/ha		14							
	no/ha		6							
Redear sunfish	gm/ha		162	163	318	233	860	815		
	no/ha		69	10	6	2	4	2		
Largemouth bass	gm/ha			155	235				2210	
	no/ha			17	8				6	
Black crappie	gm/ha		260	56		138		1440	727	
	no/ha		79	8		2		6	2	
Swamp darter	gm/ha	6	3							
	no/ha	23	6							

shad, and bluegills were abundant in the spring. Bluespotted sunfish and bluegills were collected at high densities. In the fall, bluegills, golden topminnows, mosquitofish, and golden shiners were numerically dominant. In the spring, high densities of bluespotted sunfish and golden shiners were collected. Florida gar, taillight shiners, golden topminnows, flagfish, mosquitofish and sailfin mollies were collected only in the fall. Gizzard shad and brown bullheads were collected only in the spring. Other notable temporal differences included higher biomass of redear sunfish and black crappie in the fall, higher biomass of largemouth bass in the spring, and abundant YOY chain pickerel in the spring.

Harvestable sport fish were 23% of total fish biomass in the maidencane-hydrilla habitat. The relatively low weight of harvestable sport fish included 10.3 kg/ha chain pickerel, 3.0 kg/ha warmouth, 7.6 kg/ha bluegill, 1.9 kg/ha redear sunfish, and 2.2 kg/ha black crappie. Percent harvestable sport fish was higher in fall than spring, primarily due to higher abundance of harvestable chain pickerel.

F/P ratios were relatively high in the maidencane-hydrilla habitat. Similar to the maidencane habitat, the high ratios resulted from a generally low biomass of piscivores. Chain pickerel and Florida gar were the only piscivores ≥ 320 mm TL. F/P 40 and F/P 120 were lower in the spring, due, in part, to the abundance of warmouth and black crappie.

Moderately high biomass and low density of fish were collected in the spatterdock habitat. Biomass was similar but density was approximately three times higher in the spring than in the fall. Golden shiners and bluegills were the most abundant fish by weight and number. Golden shiners were predominantly <160 mm and bluegills were predominantly <80 mm (Table 45). Abundant species by weight in the fall included Florida gar, golden shiners, bluegills, chain

Table 45. Annual mean biomass (gm/ha) and density (no/ha) of fish collected by blocknet-rotenone in the spatterdock habitat, Orange Lake, 1982-1983.

Species		Size Class (mm TL)								
		0-39	40-79	80-119	120-159	160-199	200-239	240-279	280-319	>320
Florida gar	gm/ha							89	339	6840
	no/ha							2	4	6
Bowfin	gm/ha									3446
	no/ha									2
Gizzard shad	gm/ha									1123
	no/ha									2
Chain pickerel	gm/ha	2	39	49			796		688	7360
	no/ha	10	44	12			2		4	19
Golden shiner	gm/ha		1985	9002	2042	1328	646	333		
	no/ha		790	1806	179	38	6	2		
Lake chubsucker	gm/ha			67	126	298	1046	554	2658	1048
	no/ha			4	4	4	8	2	6	2
Golden topminnow	gm/ha	4	6							
	no/ha	10	6							
Bluefin killifish	gm/ha	393								
	no/ha	1054								
Mosquitofish	gm/ha	28	23							
	no/ha	148	35							
Least killifish	gm/ha	1								
	no/ha	15								
Brook silverside	gm/ha	2	14							
	no/ha	10	19							
Banded pygmy sunfish	gm/ha	4								
	no/ha	8								
Bluespotted sunfish	gm/ha	258	1165							
	no/ha	506	683							

Table 45. Continued.

Species		Size Class (mm TL)								
		0-39	40-79	80-119	120-159	161-199	200-239	240-279	280-319	>320
Warmouth	gm/ha	21	347	232	616	1765				
	no/ha	33	160	12	12	15				
Bluegill	gm/ha	20	2405	3990	1640	3109	1892	1304		
	no/ha	40	831	267	38	29	8	4		
Dollar sunfish	gm/ha		88	8						
	no/ha		23	2						
Redear sunfish	gm/ha		252	341	345			573		
	no/ha		56	25	6			2		
Largemouth bass	gm/ha			74	186	185			690	6423
	no/ha			4	6	2			2	8
Black crappie	gm/ha		93	82			544		812	1558
	no/ha		25	12			4		2	2
Swamp darter	gm/ha	12	6							
	no/ha	38	10							

pickerel, and lake chubsuckers. High biomass of golden shiners, bluegills and largemouth bass were collected in the spring. Only golden shiners were present at high density in the fall. In the spring, high densities of golden shiners, bluespotted sunfish, bluefin killifish and bluegills were collected. Bowfin and sailfin mollies were present at low densities only in the fall. Gizzard shad, least killifish, brook silversides and banded pygmy sunfish were collected only in the spring. Other notable temporal differences between sampling periods were the higher abundance of redear sunfish and black crappie in the fall.

Harvestable sport fish were 34% of the total fish biomass in the spatterdock habitat. The moderate biomass of harvestable sport fish was comprised of 7.4 kg/ha chain pickerel, 1.8 kg/ha warmouth, 6.3 kg/ha bluegill, 0.6 kg/ha redear sunfish, 6.4 kg/ha largemouth bass, and 2.9 kg/ha black crappie. Biomass and percent biomass of harvestable sport fish was higher in the spring due primarily to the high biomass of largemouth bass at this time.

F/P ratios ranged from 2.61 for 120-199 mm TL piscivores to 0.81 for 40-119 mm TL piscivores. The low ratios for small piscivores resulted from low biomass of <40 mm TL fish and moderately abundant 40-119 mm TL chain pickerel, warmouth and black crappie. Florida gar, chain pickerel, and largemouth bass contributed approximately equal biomass to the F/P ratio for piscivores ≥ 320 mm TL. Ratios were consistently higher in the spring due to increased biomass of forage fish.

The highest biomass and density of fish were collected in the spatterdock-hydrilla habitat. Biomass and density were higher in the spring. Largemouth bass, bluegill, golden shiner and chain pickerel were abundant by weight. Harvestable (≥ 320 mm TL) largemouth bass were prevalent (Table 46). Most bluegill were <80 mm TL. Golden shiners <120 mm TL were most prevalent; however, larger golden shiners were more common than in other habitats. High

Table 46. Annual mean biomass (gm/ha) and density (no/ha) of fish collected by blocknet-rotenone in the spatterdock-hydrilla habitat, Orange Lake, 1982-1983.

Species		Size Class (mm TL)								
		0-39	40-79	80-119	120-159	160-199	200-239	240-279	280-319	>320
Florida gar	gm/ha									1869
	no/ha									4
Bowfin	gm/ha									5744
	no/ha									4
Chain pickerel	gm/ha	37	71	15			108	796		12582
	no/ha	56	96	6			2	8		25
Goldenshiner	gm/ha	6	3452	5297	1664	705	681	2317	4215	842
	no/ha	2	1485	1115	94	17	8	12	17	2
Taillight shiner	gm/ha		25							
	no/ha		17							
Lake chubsucker	gm/ha		10	207	161	415	719	904	1617	2533
	no/ha		2	23	6	4	4	2	4	4
Golden topminnow	gm/ha	90	223							
	no/ha	231	185							
Flagfish	gm/ha	3	34							
	no/ha	2	17							
Bluefin killifish	gm/ha	886	76							
	no/ha	2369	112							
Mosquitofish	gm/ha	100	22							
	no/ha	448	31							
Least killifish	gm/ha	2								
	no/ha	17								
Sailfin molly	gm/ha		2							
	no/ha		2							
Brook silverside	gm/ha		20	3						
	no/ha		21	2						
Banded pygmy sunfish	gm/ha	5								
	no/ha	21								

Table 46. Continued.

Species		Size Class (mm TL)								
		0-39	40-79	80-119	120-159	160-199	200-239	240-279	280-319	>320
Bluespotted sunfish	gm/ha	3515	4840							
	no/ha	8294	3619							
Warmouth	gm/ha	102	1524	796	1267	1291	835			
	no/ha	158	792	48	21	12	4			
Bluegill	gm/ha	186	3336	2055	1806	3148	4810	4835		
	no/ha	371	1640	154	40	27	25	15		
Dollar sunfish	gm/ha		215							
	no/ha		71							
Redear sunfish	gm/ha	21	707	390	284	262				
	no/ha	25	308	35	6	2				
Largemouth bass	gm/ha		10	271	86	193	248	781	2740	19757
	no/ha		2	31	4	2	2	4	8	35
Black crappie	gm/ha		120						698	1275
	no/ha		44						2	2
Swamp darter	gm/ha	4	9							
	no/ha	8	21							

biomass of chain pickerel, golden shiner, and bowfin were collected in the fall. Largemouth bass, bluegills, golden shiners, and bluespotted sunfish were abundant by weight in the spring. High densities of bluespotted sunfish, golden shiners, bluefin killifish and bluegills were collected in the fall and the spring. Bowfin, taillight shiners, flagfish, and sailfin mollies were collected only in the fall. Florida gar were collected only in the spring. Other notable temporal differences included the increased abundance of bluespotted sunfish, bluegills, largemouth bass, and black crappie in the spring and the high biomass of adult chain pickerel in the fall.

Harvestable sport fish were 45% of the total fish biomass in the spatterdock-hydrilla habitat. The high biomass of harvestable sport fish included 12.6 kg/ha chain pickerel, 2.1 kg/ha warmouth , 12.8 kg/ha bluegill, 0.3 kg/ha redear sunfish, 19.8 kg/ha largemouth bass, and 2.0 kg/ha black crappie. Large harvestable bluegills and largemouth bass were more abundant in the spatterdock-hydrilla habitat than in other habitats. Biomass and percent biomass of harvestable sport fish were higher in the spring than the fall.

F/P ratios for intermediate-sized piscivores were higher in the spatterdock-hydrilla habitat than other Orange Lake habitats. F/P ratios for small and large piscivores were lower than in other habitats. The low F/P 40 was due to abundant warmouth. The low F/P 320 was primarily due to the high biomass of chain pickerel and largemouth bass. There was no trend in F/P ratios over time. F/P 320 was similar in the fall and the spring as a result of concommitantly increased biomass of forage fish and large piscivores.

Intermediate biomass and density of fish were collected in the hydrilla habitat. Fish biomass was lower but density was higher in the spring than in the fall. Bluegills and redear sunfish were most abundant by weight.

High biomass of these two species and Florida gar and bowfin were collected in the fall. Bluegills, golden shiners and gizzard shad biomass were relatively high in the spring. High densities of bluefin killifish, bluegills, and bluespotted sunfish were collected in the hydrilla habitat. High densities of these fish were collected in the fall and the spring. Small warmouth were also relatively abundant in the fall. Florida gar, bowfin, taillight shiners, flagfish, least killifish, sailfin mollies, and dollar sunfish were collected only in the fall. Gizzard shad were collected only in the spring in this habitat. Additional temporal differences included the increased abundance of bluefin killifish, bluespotted sunfish, and large golden shiners and the decreased abundance of warmouth, bluegill and redear sunfish in the spring.

The relatively high biomass of harvestable sport fish was 48% of the total biomass of fish collected in the hydrilla habitat. This biomass of harvestable fish included 4.7 kg/ha chain pickerel, 1.5 kg/ha warmouth, 10.9 kg/ha bluegill, 11.7 kg/ha redear sunfish, 1.2 kg/ha largemouth bass, and 7.0 kg/ha black crappie (Table 47). Biomass of harvestable sport fish was considerably higher in the fall, but percent of total fish biomass was similar in both sampling periods.

F/P ratios in the hydrilla habitat were intermediate to values in other habitats. The relatively low F/P 320 resulted from abundant Florida gar and bowfin; these two species constituted 53% of the large piscivore biomass. There was moderate biomass of small and intermediate-size forage fish and relatively low biomass of 80-119 mm TL forage fish. Except for 200-319 mm TL piscivores, F/P ratios were higher in the spring due to the decreased abundance of piscivores.

Averaging data for the six habitats in Orange Lake, bluegills and golden shiners were the dominant fish by weight and bluespotted sunfish, bluefin killifish,

Table 47. Annual mean biomass (gm/ha) and density (no/ha) of fish collected by blocknet-rotenone in the hydrilla habitat, Orange Lake, 1982-1983.

Species		0-39	40-79	80-119	120-159	160-199	200-239	240-279	280-319	>320
Florida gar	gm/ha									7517
	no/ha									10
Bowfin	gm/ha									5271
	no/ha									2
Gizzard shad	gm/ha									5415
	no/ha									10
Chain pickerel	gm/ha	9	151	30						4740
	no/ha	54	210	4						10
Golden shiner	gm/ha		1015	2472	1067					
	no/ha		504	360	54					
Taillight shiner	gm/ha		10							
	no/ha		15							
Golden topminnow	gm/ha	82	101							
	no/ha	258	119							
Flagfish	gm/ha	2	3							
	no/ha	2	2							
Bluefin killifish	gm/ha	569	6							
	no/ha	4008	10							
Mosquitofish	gm/ha	72	2							
	no/ha	335	4							
Least killifish	gm/ha	2								
	no/ha	23								
Sailfin molly	gm/ha	3								
	no/ha	8								

Table 47. Continued.

Species		Size Class (mm TL)								
		0-39	40-79	80-119	120-159	160-199	200-239	240-279	280-319	>320
Brook silverside	gm/ha		3	6						
	no/ha		8	2						
Bluespotted sunfish	gm/ha	872	321							
	no/ha	2148	252							
Warmouth	gm/ha	52	176	235	421	1141	315			
	no/ha	98	121	10	8	10	2			
Bluegill	gm/ha	364	5215	1340	1310	3123	5642	2165		
	no/ha	708	2510	102	25	29	23	8		
Dollar sunfish	gm/ha		11							
	no/ha		4							
Redear sunfish	gm/ha	102	102	214	358	1901	6313	3477		
	no/ha	35	35	15	8	17	31	10		
Largemouth bass	gm/ha				219			478	1577	1246
	no/ha				8			2	4	2
Black crappie	gm/ha		116	29	155		335	1192	5492	
	no/ha		38	4	6		2	6	17	
Swamp darter	gm/ha	10	4							
	no/ha	46	10							

bluegills, and golden shiners were the dominant fish by number in Orange Lake. Biomass and density of fish averaged across all six habitats were similar in the fall and the spring. In the fall, high biomass of bluegills, chain pickerel, and golden shiners and high densities of bluegills, bluefin killifish, and golden shiners were collected. In the spring, golden shiners were collected in highest average biomass followed by bluegills and largemouth bass. Bluespotted sunfish were most abundant by number followed by high densities of bluefin killifish, golden shiners, and bluegills in the spring samples. There were large temporal differences in abundance of several species. Florida gar, bowfin, large chain pickerel, golden topminnows, mosquitofish, and redear sunfish were more abundant in the fall. Gizzard shad, bluespotted sunfish, and largemouth bass were more abundant in the spring.

Lake average biomass and percent biomass of harvestable sport fish were similar in fall and spring. F/P ratios for 40-119 and for 120-199 mm piscivores were lower in the fall and F/P ratio for 200-319 mm piscivores, were lower in the fall and the F/P ratio for 200-319 mm piscivores was lower in the spring. The F/P ratio for large predators was markedly higher in the spring as a result of decreased abundance of Florida gar, bowfin and chain pickerel and increased abundance of golden shiners.

Lake Henderson

The open water habitat had lower biomass and density of fish than other Lake Henderson habitats (Table 48). Biomass and density were much higher in the fall than the spring (Tables 49, 50). Threadfin shad, gizzard shad and lake chubsuckers were most abundant by weight. Gizzard shad and lake chubsuckers collected were large individuals (Table 51). High biomass of these species plus black crappie and bluegills were collected in the fall. Moderate biomass of threadfin shad, Florida gar, and gizzard shad were collected

Table 48. Mean annual biomass (gm/ha) and density (no/ha) of fish collected by blocknet-rotenone in Lake Henderson, 1982-1983.

Species		Habitat			
		Maidencane	Spatterdock	Open Water	Lake Average
Florida gar	gm/ha	2729	477	3698	2301
	no/ha	4	2	4	3
Gizzard shad	gm/ha	9340	1875	11832	7682
	no/ha	19	6	40	22
Threadfin shad	gm/ha	4028	86	17420	7178
	no/ha	273	6	1442	574
Chain pickerel	gm/ha	19967	17211	2227	13135
	no/ha	27	19	2	16
Golden shiner	gm/ha	56300	4333		20211
	no/ha	1954	181		712
Taillight shiner	gm/ha	460		213	224
	no/ha	1292		458	583
Lake chubsucker	gm/ha	92640	4629	10365	35878
	no/ha	385	17	35	146
Golden topminnow	gm/ha	424			141
	no/ha	610			203
Bluefin killifish	gm/ha	173	77		83
	no/ha	669	300		323
Mosquitofish	gm/ha	1736	5	1	581
	no/ha	7483	29	2	2505

Table 48. Continued.

Species		Habitat Maidencane	 Spatterdock	 Open Water	Lake Average
Least killifish	gm/ha	12	1		4
	no/ha	150	2		51
Sailfin molly	gm/ha	34			11
	no/ha	58			19
Brook silverside	gm/ha	29	2	7	13
	no/ha	83	2	12	32
Sunshine bass	gm/ha	872			291
	no/ha	8			3
Bluespotted sunfish	gm/ha	1850	239	236	775
	no/ha	1104	169	121	465
Warmouth	gm/ha	12341	925	222	4496
	no/ha	1573	223	106	634
Bluegill	gm/ha	53200	14248	6572	24673
	no/ha	1108	429	183	573
Dollar sunfish	gm/ha	283	38		107
	no/ha	102	10		37
Redear sunfish	gm/ha	19361	2449	1983	7931
	no/ha	1023	108	10	414
Largemouth bass	gm/ha	80316	23758	5943	36672
	no/ha	227	60	29	105

Table 48. Continued.

Species		Habitat Maidencane	 Spatterdock	 Open Water	Lake Average
Black crappie	gm/ha	6226	1003	5543	4257
	no/ha	98	4	27	43
Swamp darter	gm/ha	34	5	9	16
	no/ha	71	12	21	35
Total	gm/ha	362355	71361	66271	166660
	no/ha	18344	1581	2594	7498
Total Number species		22	18	15	18
Harvestable sport fish	gm/ha	132887	49326	16175	66129
Percent harvestable sport fish by weight		37	69	24	43

Table 49. Mean biomass (gm/ha) and density (no/ha) of fish collected by blocknet-rotenone in Lake Henderson, Fall 1982.

Species		Habitat Maidencane	Spatterdock	Open Water	Lake Average
Florida gar	gm/ha		954		318
	no/ha		4		1
Gizzard shad	gm/ha		3750	16323	6691
	no/ha		13	58	32
Threadfin shad	gm/ha	287	173	26987	9149
	no/ha	33	13	2229	758
Chain pickerel	gm/ha	29133	24258	4454	19282
	no/ha	33	21	4	19
Golden shiner	gm/ha	58362	4206		20856
	no/ha	1733	96		610
Taillight shiner	gm/ha	237		36	91
	no/ha	600		92	231
Lake chubsucker	gm/ha	129132	6958	20729	52273
	no/ha	583	25	71	226
Golden topminnow	gm/ha	808			269
	no/ha	1183			394
Bluefin killifish	gm/ha	310	137		149
	no/ha	1200	567		589
Mosquitofish	gm/ha	3358	2		1120
	no/ha	14333	8		4780
Least killifish	gm/ha	20	<1		7
	no/ha	267	4		90
Sailfin molly	gm/ha	68	3		24
	no/ha	117	4		40
Brook silverside	gm/ha	35		14	16
	no/ha	150		25	58

Table 49. Continued.

Species		Habitat Maidencane	Spatterdock	Open Water	Lake Average
Sunshine bass	gm/ha	1745			582
	no/ha	17			6
Bluespotted sunfish	gm/ha	3542	407	473	1474
	no/ha	2067	304	242	871
Warmouth	gm/ha	16992	850	443	6095
	no/ha	2667	317	213	1065
Bluegill	gm/ha	52567	16180	10381	26376
	no/ha	1467	533	313	771
Dollar sunfish	gm/ha	262	18		93
	no/ha	150	13		54
Redear sunfish	gm/ha	30252	4407	3738	12799
	no/ha	1650	171	187	669
Largemouth bass	gm/ha	88635	30082	7936	42218
	no/ha	267	83	46	132
Black crappie	gm/ha	7015	1763	10662	6480
	no/ha	150	4	50	68
Swamp darter	gm/ha	57	5	16	26
	no/ha	117	8	29	51
Total	gm/ha	422817	94153	102192	206388
	no/ha	28784	2188	3559	11515
Total number species		20	18	13	
Harvestable sportfish	gm/ha	142723	63225	28155	78034
Percent harvestable sportfish		34	63	27	41

Table 50. Mean biomass (gm/ha) and density (no/ha) of fish collected by blocknet-rotenone in Lake Henderson, Spring 1983.

Species		Habitat Maidencane	Spatterdock	Open Water	Lake Average
Florida gar	gm/ha	5458		7396	4285
	no/ha	8		8	5
Gizzard shad	gm/ha	18679		7342	8674
	no/ha	37		21	19
Threadfin shad	gm/ha	7769		7853	5207
	no/ha	513		654	389
Chain pickerel	gm/ha	10800	10163		6988
	no/ha	21	17		13
Golden shiner	gm/ha	54237	4460		19566
	no/ha	2175	267		814
Taillight shiner	gm/ha	684		390	358
	no/ha	1983		825	936
Lake chubsucker	gm/ha	56148	2300		19483
	no/ha	187	8		65
Golden topminnow	gm/ha	40			13
	no/ha	37			12
Bluefin killifish	gm/ha	37	15		17
	no/ha	137	33		57
Mosquitofish	gm/ha	113	9	<1	41
	no/ha	633	50	4	229
Least killifish	gm/ha	4			1
	no/ha	33			11
Sailfin molly	gm/ha				
	no/ha				

Table 50. Continued.

Species		Habitat Maidencane	Spatterdock	Open Water	Lake Average
Brook silverside	gm/ha	23			8
	no/ha	17			6
Sunshine bass	gm/ha				
	no/ha				
Bluespotted sunfish	gm/ha	158	72		77
	no/ha	142	33		58
Warmouth	gm/ha	7690	1000		2897
	no/ha	479	129		203
Bluegill	gm/ha	53834	12316	2764	22971
	no/ha	750	325	54	376
Dollar sunfish	gm/ha	304	57		120
	no/ha	54	8		21
Redear sunfish	gm/ha	8471	491	229	3064
	no/ha	396	46	33	158
Largemouth bass	gm/ha	71997	17434	3950	31127
	no/ha	187	37	13	79
Black crappie	gm/ha	5436	243	425	2035
	no/ha	46	4	4	18
Swamp darter	gm/ha	11	5	2	6
	no/ha	25	17	13	18
Total	gm/ha	301893	48565	30351	126937
	no/ha	7860	974	1629	3487
Total number species		20	13	10	
Harvestable sportfish	gm/ha	123050	35425	4193	54223
Percent harvestable sportfish		41	73	14	43

Table 51. Annual mean biomass (gm/ha) and density (no/ha) of fish collected by blocknet-rotenone in the open water habitat, Lake Henderson, 1982-1983.

Species		Size Class (mm TL)								
		0-39	40-79	80-119	120-159	160-199	200-239	240-279	280-319	>320
Florida gar	gm/ha									3698
	no/ha									4
Gizzard shad	gm/ha					424			2658	8750
	no/ha					12			8	18
Threadfin shad	gm/ha			8681	8739					
	no/ha			954	488					
Chain pickerel	gm/ha									2227
	no/ha									2
Taillight shiner	gm/ha	53	160							
	no/ha	208	208							
Lake chubsucker	gm/ha					279	738	1654	2908	4785
	no/ha					4	6	6	6	10
Mosquitofish	gm/ha	1								
	no/ha	2								
Brook silverside	gm/ha	1	7							
	no/ha	2	10							
Bluespotted sunfish	gm/ha	18	219							
	no/ha	21	100							
Warmouth	gm/ha	14	123	84						
	no/ha	42	60	4						
Bluegill	gm/ha	7	176	1079	172	2286	2852			
	no/ha	17	62	71	2	17	15			
Redear sunfish	gm/ha	5	228	323	752	319	356			
	no/ha	10	52	27	15	4	2			
Largemouth bass	gm/ha				42		1765	954		3181
	no/ha				2		12	4		10

Table 51. Continued.

Species		Size Class (mm TL)								
		0-39	40-79	80-119	120-159	160-199	200-239	240-279	280-319	>320
Black crappie	gm/ha		11	62	161	357				4952
	no/ha		2	6	6	4				8
Swamp darter	gm/ha	1	8							
	no/ha	6	15							

in the spring. Threadfin shad were numerically dominant, due to their abundance in the fall. Taillight shiners were relatively abundant in the spring. Chain pickerel, lake chubsuckers, brook silversides, bluespotted sunfish and warmouth were collected only in the fall. Florida gar and mosquitofish were collected only in the spring. Other temporal differences included the higher biomass of redear sunfish and largemouth bass in the fall.

Harvestable sport fish in the open water habitat were 24% of the total fish biomass (Table 48). The low biomass of harvestable sport fish included 2.2 kg/ha chain pickerel, 5.1 kg/ha bluegill, 0.7 kg/ha redear sunfish, 3.2 kg/ha largemouth bass, and 5.0 kg/ha black crappie. Harvestable sport fish biomass and percent of total biomass were higher in the fall.

F/P ratios were generally higher in the open water habitat than in other habitats (Table 41). F/P ratios for piscivores ≥ 200 (F/P 200, F/P 320) were lower in the spring than the fall due to the reduced threadfin shad biomass in the spring (Table 43).

Highest biomass, density and diversity of fish in Lake Henderson were collected in the maidencane habitat. Biomass and density were higher in the fall. Lake chubsuckers, largemouth bass, golden shiners and bluegills were most abundant by weight. Most individuals of these species were large (Table 52). High biomass of these species and redear sunfish and threadfin shad were collected in the fall. In the spring, abundant species by weight included largemouth bass, lake chubsuckers, golden shiners, bluegills, gizzard shad, and chain pickerel. Fish present in high densities included mosquitofish, golden shiners, and warmouth. High densities of mosquitofish, warmouth, bluespotted sunfish, golden shiners, redear sunfish, and bluegills were collected in the fall. Only golden shiners and taillight shiners were collected at high densities in the spring. Community composition was similar over time. Sailfin mollies and

Table 52. Annual mean biomass (gm/ha) and density (no/ha) of fish collected by blocknet-rotenone in the maidencane habitat, Lake Henderson, 1982-1983.

Species		Size Class (mm TL)								
		0-39	40-79	80-119	120-159	160-199	200-239	240-279	280-319	>320
Florida gar	gm/ha									2729
	no/ha									4
Gizzard shad	gm/ha									7271
	no/ha									12
Threadfin shad	gm/ha			1029	2830	169				
	no/ha			94	175	4				
Chain pickerel	gm/ha			29						19938
	no/ha			4						23
Golden shiner	gm/ha			1969	21390	23984	6431	2525		
	no/ha			185	1085	596	71	17		
Taillight shiner	gm/ha	190	271							
	no/ha	912	379							
Lake chubsucker	gm/ha			208	867	2237	22096	25862	8892	32479
	no/ha			17	25	27	146	100	21	50
Golden topminnow	gm/ha	116	308							
	no/ha	319	292							
Bluefin killifish	gm/ha	146	28							
	no/ha	608	60							
Mosquitofish	gm/ha	1429	307							
	no/ha	7025	458							
Least killifish	gm/ha	12								
	no/ha	150								
Sailfin molly	gm/ha	28	7							
	no/ha	50	8							
Brook silverside	gm/ha	4	25							
	no/ha	33	50							
Sunshine bass	gm/ha						872			
	no/ha						8			

Table 52. Continued.

Species		Size Class (mm TL) 0-39	40-78	80-119	120-159	160-199	200-239	240-279	280-319	>320
Bluespotted sunfish	gm/ha	91	1759							
	no/ha	198	906							
Warmouth	gm/ha	142	2950	3898	3990	756	1638			
	no/ha	281	1006	210	81	6	8			
Bluegill	gm/ha	94	1283	3031	3953	18010	25504	1325		
	no/ha	190	348	208	79	154	125	4		
Dollar sunfish	gm/ha	5	237	42						
	no/ha	10	88	4						
Redear sunfish	gm/ha		1769	3446	9126	5021				
	no/ha		548	254	177	44				
Largemouth bass	gm/ha			275	922	2202	2250	12490	4962	57214
	no/ha			17	27	42	17	56	15	54
Black crappie	gm/ha			344	809	1637	2321			1115
	no/ha			33	25	21	17			2
Swamp darter	gm/ha	6								
	no/ha	17								

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sunshine bass (white bass x striped bass hybrid) were collected only in the fall. Florida gar and gizzard shad were collected only in the spring.

Harvestable sport fish in the maidencane habitat were 37% of the total fish biomass. The high sport fish biomass included 19.9 kg/ha chain pickerel, 2.4 kg/ha warmouth, 44.6 kg/ha bluegill, 5.0 kg/ha redear sunfish, 57.2 kg/ha largemouth bass, and 3.4 kg/ha black crappie. The harvestable bluegills and largemouth bass were large, averaging 158 g and 1,060 g, respectively. Biomass of harvestable sport fish was higher in the fall, but percent harvestable sport fish was higher in the spring.

F/P ratios in the maidencane habitat were intermediate compared to other Lake Henderson habitats. The low ratio for small piscivores (F/P 40) was strongly affected by the biomass of largemouth bass. F/P ratios were consistently higher in March due to lower abundance of forage fish at this time.

Biomass of fish in the spatterdock habitat was similar to open water biomass and density was lowest of all stations. Biomass and density were higher in the fall. Largemouth bass, chain pickerel, and bluegills were most abundant by weight in both sampling periods. Most largemouth bass were 120-159 mm TL and ≥ 320 mm TL (Table 53). Most chain pickerel were ≥ 320 mm TL. The majority of bluegillss were 40-119 mm TL. Bluegill and bluefin killifish were collected in highest numerical abundance. Bluegills were collected at relatively high densities in the fall and the spring. Bluefin killifish were present in high densities only in the fall. In addition to the 13 species collected in the spring, Florida gar, gizzard shad, threadfin shad, least killifish, and sailfin mollies were collected in the fall. Other temporal differences included lower biomass of redear sunfish and black crappie in the spring.

Table 53. Annual mean biomass (gm/ha) and density (no/ha) of fish collected by blocknet-rotenone in the spatterdock habitat, Lake Henderson, 1982-1983.

Species		Size Class (mm TL)								
		0-39	40-79	80-199	120-159	160-199	200-239	240-279	280-319	>320
Florida gar	gm/ha									477
	no/ha									2
Gizzard shad	gm/ha									1875
	no/ha									6
Threadfin shad	gm/ha			40	46					
	no/ha			4	2					
Chain pickerel	gm/ha		2							
	no/ha		2							
Goldenshiner	gm/ha	1	5	639	1794	287	478	1133		
	no/ha	2	2	52	98	6	6	6		
Lake chubsucker	gm/ha						242	2069	2319	
	no/ha						2	8	6	
Bluefin killifish	gm/ha	72	5							
	no/ha	292	8							
Mosquitofish	gm/ha	5								
	no/ha	29								
Least killifish	gm/ha	1								
	no/ha	2								
Brook silverside	gm/ha		2							
	no/ha		2							
Bluespotted sunfish	gm/ha	31	209							
	no/ha	54	115							
Warmouth	gm/ha	22	302	255	94	252				
	no/ha	50	154	15	2	2				
Bluegill	gm/ha	14	646	2044	1514	4650	5379			
	no/ha	25	165	146	31	40	23			

Table 53. Continued.

Species		Size Class (mm TL)								
		0-39	40-79	80-119	120-159	160-199	200-239	240-279	280-319	>320
Dollar sunfish	gm/ha	1	37							
	no/ha	2	8							
Redear sunfish	gm/ha	5	144	807	616		338	540		
	no/ha	4	48	35	17		2	2		
Largemouth bass	gm/ha			205	477	93	565	1648	694	20078
	no/ha			8	17	2	4	8	2	19
Black crappie	gm/ha					122			881	
	no/ha					2			2	
Swamp darter	gm/ha	1	5							
	no/ha	4	8							

Harvestable sport fish were 69% of the total fish biomass collected in the spatterdock habitat. The harvestable biomass included 17.2 kg/ha chain pickerel, 0.3 kg/ha warmouth , 10.0 kg/ha bluegill, 0.9 kg/ha redear sunfish, 20.1 kg/ha largemouth bass, and 0.9 kg/ha black crappie. Harvestable sport fish biomass was much higher but percent harvestable biomass was slightly lower in the fall than in the spring.

F/P 40 and F/P 320 were lower in the spatterdock habitat than in other Lake Henderson habitats. The low F/P 40 resulted from low forage fish biomass and moderate biomass of 40-119 mm TL warmouth. The low F/P 320 resulted primarily from high biomass of large chain pickerel and largemouth bass. F/P ratios were similar in both sampling periods.

Abundance of fish in Lake Henderson, averaged over three habitats, was higher than average abundance in Orange Lake (Tables 37, 50). The high average biomass was strongly affected by the high biomass in the maidencane habitat. Largemouth bass, lake chubsuckers, bluegills and golden shiners were most abundant by weight. Biomass of these species were similar over time. High biomass of chain pickerel and redear sunfish were also collected in the fall. Mosquitofish were most abundant by number; threadfin shad, golden shiners, taillight shiners, warmouth and bluegills were also collected at relatively high densities. High density of mosquitofish was collected in the fall. Taillight shiners and golden shiner were collected in relatively high densities in the spring. Additional temporal differences included higher biomass of redear sunfish and black crappie in the fall.

Based on the lake average, harvestable sport fish were 43% of the total fish biomass. This biomass included 13.1 kg/ha chain pickerel, 0.9 kg/ha warmouth, 20.0 kg/ha bluegill, 2.2 kg/ha redear sunfish, 26.8 kg/ha largemouth bass, and 3.1 kg/ha black crappie. Biomass of harvestable sport fish was higher in the fall, but percent biomass of harvestable sport fish was similar in both sampling periods.

Lake Henderson average F/P ratios were considerably lower than Orange Lake. The low ratios were affected by high biomass of chain pickerel and largemouth bass and low biomass of forage fish. Lake Henderson supported a high biomass of forage fish species; however, a high portion of this biomass was large forage fish, such as lake chubsuckers, gizzard shad, and bluegills ≥ 120 mm TL. F/P ratios were consistently lower in March, due, largely, to the decreased abundance of forage fish.

Habitat Preference

Blocknet-rotenone and electrofishing data were analyzed to determine habitat preference. Of the 22 species of fish we collected, only eight species were collected in sufficiently and consistently different abundance in different habitats to suggest preference for particular habitats.

Large Florida gar preferred the spatterdock and hydrilla habitats in Orange Lake. Florida gar were collected in the maidencane and maidencane-hydrilla habitats in the fall when hydrilla was abundant. No Florida gar were collected in the hydrilla habitat in the spring when hydrilla biomass was low. DuRant (1980) found Florida gar avoided dense hydrilla and preferred open water and spatterdock habitats. DuRant sampled Orange Lake in September-December, 1977. At this time, hydrilla covered 95% of the historically limnetic portion of Orange Lake (DuRant 1977). Holloway (1954) found Florida gar abundant in pond lily and deep water habitats. In Lake Henderson, there was no evidence for a preferred habitat for this fish. This may be related to the low biomass of submersed plants in Lake Henderson.

Gizzard and threadfin shad are typically considered pelagic fish. Gizzard shad preferred the open water habitat in both lakes. DuRant (1980) also found gizzard shad most abundant in open water in Orange Lake. Gizzard shad were relatively abundant in the maidencane habitat in Lake Henderson and maidencane-hydrilla and hydrilla habitats in Orange Lake in spring samples. The hydrilla habitat was similar to an open water habitat in the spring when hydrilla biomass was low. The maidencane habitats in both lakes were adjacent to open water. Collection of gizzard shad in these habitats is compatible with the species' open water preference. Threadfin shad were collected only in Lake Henderson. Like gizzard shad, they preferred open water but were also abundant in the maidencane habitat in the spring.

Taillight shiners preferred open water in Orange Lake. In Lake Henderson, they were more abundant in the maidencane habitat. DuRant (1980) found taillight shiners were most abundant in open water and hydrilla habitats in Orange Lake. Taillight shiners were not collected from shallow water, submersed vegetation in central Florida (Barnett and Schneider 1974). These results indicate taillight shiners prefer open water and avoid habitats with abundant submersed vegetation.

Brook silversides were most abundant in the maidencane habitat in both lakes. DuRant (1980) found brook silversides exhibited no clear habitat preference in Orange Lake; however, maidencane habitats were not sampled.

Bluegills prefer vegetated habitats (Scott and Crossman 1973). Based on catch/hr by electrofishing, bluegills showed no clear habitat preference in Orange Lake. Blocknet-rotenone data, however, indicated a preference for habitats containing hydrilla in Orange Lake. DuRant (1980) found bluegill most abundant in hydrilla and spatterdock in Orange Lake. Vaughn (1975) found bluegill most abundant in maidencane in Orange Lake; however, hydrilla had not yet become abundant. Electrofishing and blocknet-rotenone data indicated bluegill preferred the maidencane habitat in Lake Henderson. Small bluegill were less abundant in the vegetated habitats in Lake Henderson than in Orange Lake. This could be due to a preference for submersed vegetation as shown by data in Barnett and Schneider (1974) and DuRant (1980) or increased vulnerability to predation (Bailey 1978).

The few redear sunfish we collected by electrofishing showed no clear habitat preference. Blocknet-rotenone data suggests redear sunfish <160 mm TL preferred the spatterdock-hydrilla habitat in Orange Lake and the maidencane habitat in Lake Henderson. DuRant (1980) found redear sunfish <100 mm TL preferred hydrilla and spatterdock in Orange Lake. Small redear sunfish were frequently collected in submersed vegetation (Barnett and Schneider 1974; Wilbur 1969). Larger redear sunfish preferred the hydrilla habitat in Orange Lake and the maidencane habitat in Lake Henderson. DuRant (1980) found $\geq$ 100 mm redear sunfish most abundant in open water in Orange Lake. Wilbur (1969) collected large redear sunfish in open water near shore. Wilbur's (1969) description of preferred habitat for large redear sunfish suggests an ecotone effect. Maidencane habitats (Lake Henderson) and hydrilla habitats (Orange Lake), which border open water, would also provide an ecotone.

Largemouth bass are typically associated with vegetation. Electroshocking catch/hour data indicated large and small largemouth bass showed no habitat preference in Orange Lake, except during spawning season when large largemouth bass were abundant in the maidencane, maidencane-hydrilla, and spatterdock-hydrilla habitats. A commonality of these three habitats is the clumped distribution of the emergent vegetation and proximity to open water. In Lake Henderson, maidencane was clearly the preferred habitat of all sizes of largemouth bass. DuRant (1980) found small largemouth bass most abundant in heavy vegetation and large largemouth bass most abundant in open water and spatterdock habitats. The variability in distribution of largemouth bass may be more dependent on availability of vulnerable food resources rather than a preference for a particular habitat type.

Black crappie ≥ 200 mm TL tended to prefer the open water habitats in both lakes. They were also relatively abundant in the Orange Lake hydrilla habitat, especially in the spring when hydrilla biomass was low. In Lake Henderson, 200-239 mm TL black crappie were most abundant in the maidencane. DuRant (1980) found black crappie exhibited no habitat preference. Scott and Crossman (1973) reviewed the literature and concluded black crappie were almost always associated with abundant growths of aquatic vegetation. It is likely that large black crappie prefer the ecotone between open water and vegetated habitats.

Most fish species collected exhibited no preference for a specific habitat type but rather were abundant in habitats with abundant macrophytic vegetation. These species included: large chain pickerel, golden shiners, lake chubsuckers, golden topminnows, flagfish, bluefin killifish, mosquitofish, least killifish, sailfin mollies, banded pygmy sunfish, bluespotted sunfish, warmouth and dollar sunfish. This result agrees with the findings of Barnett and Schneider (1974) and DuRant (1980). Except for large chain pickerel and large warmouth these species are small forms and feed on invertebrate foods. Dense vegetation provides both food and shelter for these fish. DuRant (1980) found large chain pickerel most abundant in open water and warmouth most abundant in hydrilla when hydrilla was very abundant in Orange Lake. Chain pickerel (Scott and Crossman 1973, Guillory 1979) and warmouth (Larimore 1957) are typically associated with vegetation. As suggested for largemouth bass, it is likely that these two piscivorous fish occupy those vegetated habitats where forage fish are vulnerable, rather than exhibiting a distinct preference for a particular habitat type.

In both lakes, highest mean density and biomass of the total fish community were collected in the habitats with highest plant biomass. Further, highest mean biomass of harvestable sport fish was collected in the habitat with the highest mean plant biomass in each lake.

Temporal changes in fish abundance and plant biomass in Orange Lake indicated a positive relationship between fish abundance and plant biomass. Fish biomass and plant biomass in the maidencane and hydrilla habitats were higher in fall than in spring. Fish biomass and plant biomass in the spatterdock-hydrilla habitat were higher in spring than in fall. Fish density and plant biomass in the maidencane and maidencane-hydrilla habitat were higher in the fall than in the spring. Fish density and plant biomass were higher in the spring than in the fall in the spatterdock and spatterdock hydrilla habitats. Temporal changes in harvestable fish biomass and percent harvestable fish biomass also paralleled temporal changes in plant biomass in three habitats.

Results from Orange Lake indicated total plant biomass was an important determinant of fish abundance. In addition, our results suggest composition of the plant biomass (i.e., qualitative aspects of the plant community) affected fish abundance. In Lake Henderson, fish biomass and density were higher in the fall blocknet-rotenone samples in the maidencane and spatterdock habitats but plant biomass was higher in the spring in these habitats. Since density and biomass were also lower in the open water habitat in the spring blocknet-rotenone samples, the results suggest the fish relocated to habitats not sampled by us. The decreased abundance of fish in the maidencane and maidencane-hydrilla habitats in Orange Lake in the spring paralleled the decrease of plant biomass in these habitats; however, the decreased plant biomass was largely a result of decreased biomass of submergent macrophytes. In the Orange Lake spatterdock and spatterdock-hydrilla habitats, fish abundance was highest in the spring. Submergent plant biomass was relatively high in these habitats at this time. The habitats sampled in Lake Henderson had little submergent vegetation. Lake Henderson, however, has extensive areas of marsh that contain abundant submergent macrophytes (Attardi 1983). If submergent macrophtyes are also a significant determinant of fish abundance, the marsh areas would provide a desirable habitat for fish in Lake Henderson. Preferential use of these habitats in the spring would account for the decreased biomass and density of fish in the open water and the vegetated habitats adjacent to the open water studied.

The absence of distinct habitat preferences for most fish species, except pelagic species, and the maximum abundance of fish in different habitat types in the two lakes studied indicates macrophyte species are not primary determinants of fish distribution and abundance. Plant biomass, or an alternate measure of macrophyte abundance, such as stem density, does affect the abundance and distribution of fish. Composition of the plant biomass also affected fish abundance. Submergent vegetation has been shown to provide habitat for many small fish (Barnett and Schneider 1974). In our studies, abundance of fish was, in general, positively related to abundance of submergent vegetation, and submergent vegetation seems to be especially important in the spring. The abundance of fish in the Lake Henderson maidencane habitat, the only habitat with a high biomass of floating macrophytes when blocknet-rotenone sampling was conducted, suggest floating plants also affected fish abundance.

Condition Factor

Average condition factors (KTL) for size groups of chain pickerel, bluegill and largemouth bass were compared between Orange Lake and Lake Henderson. Comparisons were not possible for redear sunfish and black crappie due to small sample size.

Between lake comparisons of chain pickerel KTL was limited to size groups ≥ 440 mm due to absence of smaller fish in our electroshocking samples in Lake Henderson. Although sample size prevented meaningful statistical comparison, Lake Henderson chain pickerel had consistently higher KTL's (Table 54).

Bluegill KTL was generally higher in Lake Henderson (Table 55). KTL's for 120-159 mm and 160-199 mm fish were significantly higher (Sign test, $p<0.05$) in Lake Henderson. KTL's for 241-279 mm bluegill were higher in Lake Henderson for all comparisons. KTL's for 200-239 mm bluegill were higher in Lake Henderson in October, February and August and higher in Orange Lake in December, April and June.

KTL of largemouth bass were not significantly different (Sign test, $p \geq 0.05$) between lakes. KTL's of largemouth bass <360 mm were similar (Table 56); KTL's of largemouth bass <360 mm were higher in Lake Henderson in 13 of 25 possible size-class-date comparisons. KTL of largemouth bass ≥ 360 were generally higher in Lake Henderson; KTL's for ≥ 360 mm largemouth bass were higher in Lake Henderson in 14 of 19 possible size-class-date comparisons.

Table 54. Condition factors of chain pickerel in Orange Lake and Lake Henderson, October 1982–August 1983. Numbers in parentheses are number of fish.

Size Class (mm TL)	Sex	Orange Lake Oct	Dec	Feb	Apr	Jun	Aug	Lake Henderson Oct	Dec	Feb	Apr	Jun	Aug
240–279	MF												
280–319	MF	0.52(6)	0.60(2)	0.55(1)									
320–359	M	0.57(4)	0.53(4)	0.55(1)									
320–359	F	0.50(3)	0.54(3)	0.49(1)									
360–399	M	0.60(3)	0.54(7)	0.54(5)	0.54(2)	0.52(1)	0.57(1)						
360–399	F	0.55(2)	0.51(3)	0.54(1)	0.58(1)								
400–439	M	0.57(4)	0.58(6)	0.50(5)		0.63(2)							
400–439	F	0.59(3)	0.47(1)	0.54(1)			0.68(1)						
440–479	M	0.61(5)	0.60(1)	0.50(2)			0.54(5)	0.62(1)	0.60(2)	0.50(1)			
440–479	F	0.56(5)	0.53(1)	0.49(1)		0.65(1)	0.58(1)	0.59(1)				0.68(1)	
480–519	M		0.60(2)	0.52(1)		0.53(1)		0.65(2)	0.65(1)		0.61(1)		
480–519	F	0.58(1)	0.50(1)	0.53(1)	0.57(1)	0.51(1)	0.58(2)	0.52(1)		0.49(1)	0.69(1)	0.80(1)	
≥520	M		0.61(2)										
≥520	F		0.54(3)	0.53(1)		0.61(1)	0.54(1)		0.60(2)			0.64(3)	

Table 55. Condition factors of bluegill in Orange Lake and Lake Henderson, October 1982–August 1983. Numbers in parentheses are number of fish.

Size Class (mm TL)	Orange Lake Oct	Dec	Feb	Apr	Jun	Aug	Lake Henderson Oct	Dec	Feb	Apr	Jun	Aug
120–159	1.71(14)	1.66(6)	1.90(8)	1.89(4)	1.84(5)	1.87(1)	1.98(2)	2.04(5)		2.00(5)	2.06(13)	2.01(5)
160–199	2.00(3)	1.98(6)	2.11(15)	2.10(6)	2.09(3)	2.04(3)	2.15(10)	2.18(7)	2.25(2)	2.24(3)	2.43(5)	2.41(7)
200–239	2.13(2)	2.56(4)	2.40(46)	2.45(29)	2.49(3)	2.26(10)	2.44(13)	2.37(9)	2.44(7)	2.33(3)	2.46(26)	2.45(21)
240–279	1.40(1)		2.30(9)	2.51(7)		2.10(1)	1.68(1)	2.32(1)	2.34(1)		2.21(1)	2.26(2)

Table 56. Condition factor of largemouth bass in Orange Lake and Lake Henderson, October 1982-August 1983. Numbers in parentheses are number of fish.

Size Class (mm TL)	Sex	Orange Lake						Lake Henderson					
		Oct	Dec	Feb	Apr	Jun	Aug	Oct	Dec	Feb	Apr	Jun	Aug
200-239	MF	1.20(3)	1.08(3)	1.24(3)			1.33(2)	1.28(3)	1.29(3)	1.19(1)	1.25(4)	1.35(5)	1.26(4)
240-279	MF	1.20(1)	1.22(3)	1.22(3)	1.27(1)			1.34(4)	1.39(3)	1.16(1)	1.32(11)	1.40(6)	1.33(3)
280-319	MF	1.27(4)	1.34(2)	1.38(9)	1.35(5)	1.52(1)	1.34(5)	1.49(3)	1.28(3)	1.35(1)	1.44(4)	1.40(8)	1.30(1)
320-359	M	1.31(3)	1.48(2)	1.37(7)	1.34(5)	1.48(4)	1.38(5)	1.45(6)	1.41(6)	1.56(1)	1.35(5)	1.48(2)	1.35(4)
320-359	F	1.38(3)	1.22(1)	1.30(4)		1.41(2)	1.40(2)	1.37(5)	1.36(1)	1.40(3)	1.46(1)	1.39(6)	1.41(2)
360-399	M			1.43(8)	1.29(5)	1.31(2)	1.35(3)	1.57(9)	1.50(4)	1.60(4)	1.37(5)	1.47(4)	1.48(1)
360-399	F	1.44(2)		1.42(1)	1.26(1)	1.31(3)	1.42(1)	1.27(1)	1.31(1)		1.46(2)	1.50(1)	1.42(1)
400-439	M		1.27(1)	1.44(10)	1.28(8)			1.73(1)	1.58(5)	1.53(1)		1.51(1)	
400-439	F			1.54(3)			1.28(1)	1.53(3)	1.38(1)		1.36(1)	1.45(1)	
440-479	M			1.40(5)	1.34(6)		1.46(1)			1.60(1)	1.30(1)	1.45(2)	1.44(1)
440-479	F				1.47(1)	1.34(2)	1.55(1)	1.51(1)	1.74(1)	1.59(2)	1.75(1)	1.50(4)	
480-519	M												
480-519	F				1.56(1)	1.42(1)		1.50(1)	1.44(2)		1.51(2)	1.53(1)	1.51(2)
≥520	M							0.92(1)					
≥520	F			1.67(10)	1.47(3)	1.58(1)	1.68(2)		1.71(2)	1.84(1)			1.62(4)

Food Habits

Bluegills <150 mm TL

The most frequently eaten food items of bluegills <150 mm TL in Orange Lake were insects and crustaceans (Table 57). In the maidencane habitat, dipterans were the predominant food resource. Trichopterans and lepidopterans were consumed by most bluegills but in low numbers. Amphipods were frequently eaten crustaceans and cladocerans were abundant in the diet of 40% of the small bluegills. In the maidencane-hydrilla habitat dipeterans were important insects in the bluegill diet. Numerous cladocerans were eaten by a majority of the bluegill in this habitat. Ostracods (Podocopa) were common in the diet in low numbers. In the spatterdock habitat, bluegills ate, primarily, dipteran larvae, and, secondarily, cladocerans. Half the bluegills had consumed copepods and amphipods. Frequency of full stomachs was highest in the spatterdock habitat (Table 58). Dipterans and cladocerans were the predominant food items of small bluegills in the spatterdock-hydrilla habitat. Bluegill diet was most diverse in this habitat. Frequency of full stomach was lowest in the spatterdock-hydrilla habitat. Dipterans were the primary insects and amphipods the dominant crustaceans in the bluegill diet in the hydrilla habitat. Although the bluegill diets varied among habitats the only notable differences in food habits were the prevalence of dipterans in the diet of bluegill collected in the spatterdock and spatterdock-hydrilla habitats, and the greater diversity of food organisms consumed in the spatterdock-hydrilla habitats.

Insects and crustaceans were also the most frequent food items in the diet of bluegills <150 mm TL in Lake Henderson (Table 59). Dipterans dominated the diet in the maidencane and spatterdock habitats. Cladocerans were eaten by most bluegills in relatively low numbers in both habitats. Amphipods were also eaten by most bluegills in both habitats. Water mites (Hydracarina) and trichopterans

Table 57. Annual mean number of organisms per stomach[a] (no) and frequency of occurrence (freq, %) of food items consumed by <150 mm TL bluegill, Orange Lake, October 1982-August 1983.

	Habitat											
	Maidencane		Maidencane-hydrilla		Spatterdock		Spatterdock-hydrilla		Hydrilla		Lake Average	
Taxon	No	Freq	No	Freq	No	Freq	No	Freq	No	Freq	No	Freq
Gastropoda	1	27			1	3	1	21	5	25	2	17
Crustacea	25	73	61	82	27	79	53	71	17	80	39	77
Cladocera	37	40	83	55	15	57	55	63	23	40	43	55
Eucopepoda	3	13	9	27	20	50	8	23	3	20	12	28
Podocopa	1	40	3	64	5	28	2	30	1	15	3	32
Amphipoda	5	47	1	18	3	50	3	25	6	55	4	38
Hyalella	5	47	1	18	3	50	3	25	6	55	4	38
Arachnoidea			3	36	1	21	4	27	4	5	3	20
Hydracarina			3	36	1	21	4	27	4	5	3	20
Insecta	29	100	12	82	45	93	47	96	26	80	39	94
Ephemeroptera					2	14	1	5	1	15	1	8
Caenis					1	7	1	2			1	2
Odonata	2	20	1	9	1	14	2	36	6	5	2	23
Ischnura					1	3	2	16			2	8
Enallagma	1	7					1	5			1	3
Libellula							2	2			2	1
adults	1	7					1	2			1	1
Hemiptera	2	40	1	27	2	39	1	27	2	25	2	31
Corixidae	1	20			6	3	1	5			2	5
Trichocorixa	3	13			2	32	1	20	3	5	2	18
Mesovelia							1	3	1	5	1	2
Lepidoptera	5	53	12	27	1	3	22	9	11	50	11	21
Parapoynx	4	47	12	27			10	2	11	50	9	16
adults	13	7			1	3	25	7			19	5
Coleoptera	2	7	1	9	1	14	1	5			1	8
Notomicrus					2	3	1	2			1	1
Hydroporus					1	7					1	1
larvae	2	7									2	1

Table 57. Continued.

	Habitat											
	Maidencane		Maidencane-hydrilla		Spatterdock		Spatterdock-hydrilla		Hydrilla		Lake Average	
Taxon	No	Freq	No	Freq	No	Freq	No	Freq	No	Freq	No	Freq
Trichoptera	8	60			3	36	2	34	7	35	4	35
Oxyethira	7	53			3	11	2	7	9	20	6	15
Orthotrichia	2	7			1	3	1	7	2	15	2	7
Leptocerus					1	3	1	3			1	2
Triaenodes	1	13			1	18	1	7			1	9
Oecetis	2	7			1	4	1	7			1	5
Polycentropus	6	7					3	3			4	2
Diptera	27	73	7	82	45	86	43	93	16	75	35	87
Chironomidae larvae	24	73	6	82	31	86	43	86	15	75	31	83
Chironomidae pupae	6	33	2	36	6	68	4	68	2	25	5	55
Chaoborus	1	7			28	29	2	9			17	11
Probezzia					1	3					1	1
adults	1	13	1	9	1	7	1	14			1	9
Number of stomachs containing food		15		11		28		56		20		130

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[a] Mean number of a taxon per stomach was calculated by dividing the total number of individuals of the taxon by the number of stomachs containing that taxon.

Table 58. Frequency (%) of stomachs containing food for fish collected by electrofishing in Orange Lake and Lake Henderson, October 1982-August 1983. Numbers in parentheses are number of fish collected.

Lake	Species	Size Class (mm TL)	Habitat						Lake Average
			Maidencane	Maidencane-hydrilla	Spatterdock	Spatterdock-hydrilla	Hydrilla	Open Water	
Orange	Chain pickerel	<300	50(4)	67(3)	0(1)	86(7)	(0)		67(15)
	Chain pickerel	≥300	43(35)	40(4)	13(15)	47(38)	33(12)		41(104)
	Bluegill	<150	75(20)	79(14)	85(33)	67(85)	70(27)		73(179)
	Bluegill	≥150	100(47)	98(47)	96(23)	100(24)	93(14)		98(155)
	Redear sunfish	<150	100(1)	100(2)	0(1)	0(6)	80(5)		47(15)
	Redear sunfish	≥150	100(3)	(0)	(0)	100(1)	63(8)		75(12)
	Largemouth bass	<300	62(34)	59(17)	77(31)	58(64)	61(64)		62(210)
	Largemouth bass	≥300	54(26)	57(28)	56(16)	50(58)	64(11)		54(139)
Henderson	Chain pickerel	<300	(0)		(0)			(0)	(0)
	Chain pickerel	≥300	0(9)		40(10)			(0)	21(19)
	Bluegill	<150	93(30)		86(22)			(0)	90(52)
	Bluegill	≥150	96(89)		100(34)			100(6)	97(129)
	Redear sunfish	<150	100(7)		100(1)			100(1)	100(9)
	Redear sunfish	≥150	82(11)		83(6)			(0)	82(17)
	Largemouth bass	<300	88(68)		81(52)			40(5)	83(125)
	Largemouth bass	≥300	63(64)		59(49)			77(13)	63(126)

Table 59. Annual mean number of organisms per stomach[a] (no) and frequency of occurrence (freq, %) of food items consumed by <150 mm TL bluegill, Lake Henderson, October 1982-August 1983.

Taxon	Habitat						Lake Average	
	Maidencane		Spatterdock		Open water			
	No	Freq	No	Freq	No	Freq	No	Freq
Gastropoda	I	7	2	47			2	23
Crustacea	17	86	34	100			24	91
Cladocera	8	75	25	95			16	83
Eucopepoda	1	39	8	68			5	51
Podocopa	20	18	2	37			9	26
Amphipoda	7	53	7	58			7	55
Hyalella	7	53	7	58			7	55
Arachnoidea	5	61	2	26			5	47
Hydracarina	5	61	2	26			5	47
Insecta	158	96	81	100			126	98
Ephemeroptera	2	18	2	37			2	26
Caenis	3	11	1	16			2	13
Callibaetis			1	5			1	2
Odonata			6	16			6	6
Libellula			1	5			1	2
Hemiptera			1	11			1	4
Corixidae			2	5			2	2
Coleoptera			1	16			1	6
Notomicrus			2	5			2	2
Hydroporus			1	5			1	2
Trichoptera	4	53	4	31			4	45
Orthotrichia	2	29	5	26			3	28
Leptocerus			1	5			1	2
Oecetis	4	36	1	5			4	23
Ceraclea	1	14					1	9
Diptera	156	96	77	100			123	98
Chironomidae larvae	148	96	73	100			117	98
Chironomidae pupae	8	93	5	84			7	89
Chaoborus	6	3	1	11			3	6
Probezzia			1	5			1	2
Number of stomachs containing food		28		19		0		47

[a] Mean number of a taxon per stomach was calculated by dividing the total number of individuals of the taxon by the number of stomachs containing that taxon.

were common in the bluegill diet in the maidencane habitat. Copepods were frequently eaten, but in low numbers, by bluegills in the spatterdock habitat. Comparison of diets between these two habitats shows a greater consumption of dipterans in the maidencane habitat and a greater diversity of food organisms eaten in the spatterdock habitat. Frequency of stomachs containing food was higher in the maidencane habitat (Table 58).

Comparisons between lakes indicates greater consumption of dipterans in Lake Henderson habitats and greater consumption of cladocerans in Orange Lake habitats. Frequency of full stomachs was higher in Lake Henderson.

Similar to findings of Keast (1978), Emig (1966a), and Hall et al. (1970) bluegills <150 mm in Orange Lake and Lake Henderson fed largely on insects, predominantly chironomid larvae, and crustaceans in all habitats. Small numbers of other insects were eaten at variable frequencies. The insect taxa consumed, and especially the low frequency and numbers of Chaoborus in the diet, suggest that the insects eaten by small bluegill in both lakes were primarily epiphytic insects. The crustaceans consumed included planktonic (cladocerans and copepods), benthic (osctracods, Hyalella), and epiphytic (Hyalella) varieties, precluding determination of strata or substrates from which they were consumed. The relatively high occurrence of cladocerans compared to other food items agrees with findings of Keast (1978) and Goodson (1965) that cladocerans are an important forage for small bluegill. The prevalence of cladocerans in the diet of small bluegill in Orange Lake and chironomids in the diet of Lake Henderson bluegills suggests differential availability of food resources between the two lakes. Chironomid abundance in the hydrosoil and cladocera density in the zooplankton were similar in the two lakes. Epiphytic chironomids, however, were more abundant in Lake Henderson. Hence, chironomids were eaten where they were more available. The higher frequency of full stomachs and higher KTL in Lake Henderson indicates the availability of a better food resource for <150 mm TL bluegill in Lake Henderson.

Bluegills $\geq$ 150 mm TL

Food items eaten most frequently by bluegills $\geq$ 150 mm TL in Orange Lake were insects and crustaceans (Table 60). In the maidencane habitat, dipterans, trichopterans, amphipods, and cladocerans were the most commonly consumed food organisms. Dipterans, trichopterans, cladocerans, amphipods and gastropods were the predominant taxa consumed in the maidencane-hydrilla habitat. In the spatterdock habitat, dipterans and cladocerans were the predominant forage organisms. Dipterans, trichopterans, odonates and cladocerans were frequently consumed by bluegills in the spatterdock-hydrilla habitat. Amphipods were consumed in relatively high numbers by some bluegills, and hemipterans were more prominent in the bluegill diet than in other habitats. Gastropods were also abundant in bluegill diets in the hydrilla habitat. Frequency of full stomachs was lowest in the hydrilla habitat (Table 58). Overall, insects, primarily chironomid larvae, were the dominant food in bluegill diets in all habitats except the hydrilla habitat where crustaceans and insects were eaten with equal frequency. Trichopterans were prevalent forage in the maidencane, maidencane-hydrilla and spatterdock-hydrilla habitats. Amphipods were prevalent forage in the maidencane, maidencane-hydrilla, and hydrilla habitats. Cladocerans were very abundant in the bluegill diets in the maidencane, maidencane-hydrilla and spatterdock-hydrilla habitats.

Insects and crustaceans were eaten most frequently by bluegill $\geq$ 150 mm TL in Lake Henderson (Table 61). Dipterans, trichopterans, and amphipods were the predominant food items eaten in the maidencane habitat. In the spatterdock habitat, dipterans, trichopterans, cladocerans, and amphipods were the dominant food organisms. Gastropods also occurred often in bluegill diets in this habitat. The

Table 60. Annual mean number of organisms per stomach[a] (no) and frequency of occurrence (freq, %) of food items consumed by ≥150 mm TL bluegill, Orange Lake, October 1982–August 1983.

Taxon	Habitat										Lake Average	
	Maidencane		Maidencane-hydrilla		Spatterdock		Spatterdock-hydrilla		Hydrilla			
	No	Freq	No	Freq	No	Freq	No	Freq	No	Freq	No	Freq
Gastropoda	17	32	18	63	2	27	9	46	19	61	15	46
Crustacea	607	85	1225	84	132	86	1276	71	152	100	768	86
Cladocera	849	57	1393	72	166	59	1915	46	135	69	1003	62
Eucopepoda	13	21	21	54	5	13	13	21	5	23	16	31
Podocopa	8	25	27	50	31	23	10	25	13	31	20	34
Amphipoda	35	64	22	67	15	41	58	33	53	100	33	61
Hyalella	35	64	22	67	15	41	58	33	53	100	33	61
Arachnoidea	4	11	6	11	3	18	1	4	5	8	4	11
Hydracarina	4	11	6	11	3	18	1	4	5	8	4	11
Insecta	211	91	86	96	121	91	148	100	68	100	137	97
Ephemeroptera	6	13	4	30	1	5	8	29	2	31	5	21
Caenis	5	4	8	2			3	8			5	3
Callibaetis	4	4									4	1
Odonata	14	36	13	46	6	32	12	63	18	61	13	46
Ischnura	6	11	3	11	2	14	9	21	12	38	7	15
Enallagma	22	17	17	17	2	14	6	29	8	54	13	22
Libellula					1	5	5	13			4	3
Coenagrionidae			54	2							54	1
Pantala			1	2							1	1
Plathemis					1	5					1	1
Hemiptera	14	23	6	30	8	27	18	42	7	31	11	30
Trichocorixa	15	21	6	30	7	14	19	37	7	31	11	27
Corixidae	1	2			2	9					2	2
Mesovelia					1	9	12	4			5	2
Gerris					5	5					5	1
Lepidoptera	39	15	7	13	2	5	1	8	14	23	19	13
Parapoynx	39	15	7	13			1	4	14	23	21	11

Table 60. Continued.

Taxon	Habitat										Lake Average	
	Maidencane		Maidencane-hydrilla		Spatterdock		Spatterdock-hydrilla		Hydrilla			
	No	Freq	No	Freq	No	Freq	No	Freq	No	Freq	No	Freq
Coleoptera	8	2	3	.4	2	45	3	13			3	11
Donacia					1	9					1	1
Notomicrus	8	2			6	5					7	1
Phytonomus					1	5					1	1
Phytobius			4	2	1	5					3	1
Hydroporus					1	14					1	2
Dyticidae							1	4			1	1
Trichoptera	11	68	12	65	3	27	35	71	5	38	15	60
Oxyethira			2	2			1	4			1	1
Orthotrichia	6	23	5	17	4	5	3	21	1	15	5	18
Leptocerus	7	13	10	15	2	14	40	54	2	23	20	21
Triaenodes	2	9	14	13	4	5	5	21	2	8	7	11
Oecetis	10	32	8	26	1	14	7	17	3	15	8	24
Ceraclea	5	11	7	15							6	8
Polycentropus	6	21	4	11	2	5	3	17	8	8	5	14
Diptera	190	89	68	96	120	86	105	100	49	100	116	95
Chironomidae larvae	158	85	55	85	99	86	86	96	42	92	97	89
Chironomidae pupae	41	66	11	69	14	68	30	75	6	77	23	71
Chaoborus	13	17	60	17	.97	9	5	17	15	38	32	18
Probezzia					1	5					1	1
adults	7	6	4	2							6	3
Number stomachs containing food		47		46		22		24		13		152

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[a] Mean number of a taxonper stomach was calculated by dividing the total number of individuals of the taxon by the number of stomachs containing that taxon.

Table 61. Annual mean number of organisms per stomach[a] (no) and frequency of occurrence (freq, %) of food items consumed by ≥150 mm TL bluegill, Lake Henderson, October 1982-August 1983.

	Habitat							
	Maidencane		Spatterdock		Open water		Lake Average	
Taxon	No	Freq	No	Freq	No	Freq	No	Freq
Gastropoda	5	33	8	41	8	17	6	35
Crustacea	73	75	90	94	165	83	83	81
Cladocera	17	50	90	85	3	33	45	59
Eucopepoda	4	7	3	41	3	50	3	19
Podocopa	14	36	4	38	6	17	11	35
Amphipoda	76	53	8	59	201	67	64	56
Hyalella	76	53	8	59	201	67	64	56
Arachnoidea	14	30	3	26			11	27
Hydracarina	14	30	3	26			11	27
Insecta	244	85	163	94	117	100	213	88
Ephemeroptera	3	12	3	29	4	50	3	19
Caenis	2	7			5	33	3	6
Callibaetis			9	3			9	1
Odonata	5	27	3	32	3	33	4	29
Ischnura	4	7	2	12			3	8
Enallagma	9	8	5	12	4	17	7	10
Orthemis	1	1					1	1
Anax	4	1					4	1
adults	1	1					1	1
Hemiptera	3	2	4	21			4	7
Trichocorixa	2	1	1	6			2	2
Corixidae			1	3			1	1
Mesovelia			4	6			4	2
Ranatra			2	3			2	1
Lethocerus			2	3			2	1
Lepidoptera			5	3			5	1
Parapoynx			5	3			5	1
Coleoptera	2	1	3	9			3	3
Phytonomus	2	1					2	1
Hydroporus			2	3			2	1
Galerucella			1	6			1	2
Trichoptera	7	51	8	56	2	17	7	51
Orthotrichia	4	30	6	38	2	17	5	31
Oecetis	7	32	6	36			6	31
Ceraclea	3	2	2	3			3	2
Diptera	238	85	156	94	114	100	207	88
Chironomidae larvae	223	85	145	94	108	100	194	88
Chironomidae pupae	17	70	11	76	5	100	15	73
Palpomyia					2	17	2	1
Odontomyia	4	1					4	1
Chaoborus	23	1	5	9	1	17	8	4
Probezzia	2	6	4	6	2	17	2	6
adult	1	1	1	9			1	3
Number of stomachs containing food	84		34		6		124	

Table 61. Continued.

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[a] Mean number of a taxon per stomach was calculated by dividing the total number of individuals of the taxon by the number of stomachs containing that taxon.

dominant foods of bluegills in the open water habitat included dipterans, ephemeropterans and amphipods. Overall, insects were the most frequently consumed organisms in all habitats, with chironomid larvae being the principal taxon eaten. Trichopterans were frequently eaten in the maidencane and spatterdock habitats. Amphipods were important food organisms in the maidencane and open water habitats and cladocera were important components of the bluegill diet in the spatterdock habitats.

The diet of bluegill in both lakes was primarily insects and secondarily crustaceans. Comparison between lakes revealed greater consumption of amphipods and chironomid larvae in Lake Henderson and greater consumption of cladocera in Orange Lake. Except for dipterans, bluegills ate other orders of insects more frequently in Orange Lake.

Moffet and Hunt (1943), Goodson (1965) and Keast (1978) reported that diets of large bluegill parallel those of small bluegill with insects becoming increasingly important in the diet and microcrustaceans less so as bluegill grow. Diets of large bluegill in Lake Henderson generally agreed with this pattern. In Orange Lake, however, cladocerans were a large component of the diet. This was mainly due to the great abundance of cladocerans in the diet of large bluegill collected during February, indicating planktonic microcrustaceans can be a dominant and valuable forage for large bluegill at certain times of the year. Despite the seasonal importance of cladocerans in Orange Lake, diets of large bluegill from both Lake Henderson and Orange Lake showed marked increases in number and frequency of trichopterans, odonates, Hyalella and gastropods. These results reflect the importance of macroinvertebrates, particularly epiphytic forms, in the diet of large bluegill in both lakes. As discussed for smaller fish, the higher condition factor of bluegill in Lake Henderson suggests a better food resource for large

bluegills in Lake Henderson. The greater consumption of macroinvertebrates by large bluegill in Lake Henderson reflects the higher abundance of macroinvertebrates in the Lake Henderson maidencane habitat, where most large bluegill were collected.

Largemouth Bass <300 mm TL

Food items most frequently eaten by largemouth bass <300 mm in Orange Lake were fish and crustaceans (Table 62). Fish were the principal food consumed in the maidencane habitat with mosquitofish and bluefin killifish occurring most often in the diet. Grass shrimp (Palaemonetes, Decapoda were the most commonly occurring crustaceans in subharvestable bass diets in the maidencane habitat. Insects, mainly hemipterans, were also of some importance in this habitat. Fish were also the most frequently eaten food item in the maidencane-hydrilla habitat, but collection of few fish from this habitat limited meaningful analysis of forage preference. Food species eaten included swamp darter, bluegill and mosquitofish. Grass shrimp and dipterans were recorded in 30% of the fish collected in this habitat. In the spatterdock habitat, fish were again the most frequently consumed item with bluefin killifish and bluegill being the principal species eaten. Grass shrimp were also a main part of the diet in the spatterdock habitat. Mosquitofish, bluefin killifish and least killifish were prominent fish species in the diet in the spatterdock-hydrilla habitat where fish were the most frequently occurring food item. Grass shrimp, dipterans, hemipterans and odonates were also prevalent forage organisms. In the hydrilla habitat, fish were eaten more frequently than other organisms. Mosquitofish were consumed most often. Again, grass shrimp and hemipterans were prominent in the diet in this habitat. The food habits of subharvestable largemouth bass were generally similar among habitats, but fish were more frequently eaten in the spatterdock habitat. The frequency of full stomachs was highest in the spatterdock habitat (Table 58).

Table 62. Annual mean number of organisms per stomach^{a} (no) and frequency of occurrence (freq, %) of food items consumed by < 300 mm TL largemouth bass, Orange Lake, October 1982-August 1983.

	Habitat										Lake Average	
	Maidencane		Maidencane-hydrilla		Spatterdock		Spatterdock-hydrilla		Hydrilla			
Taxon	No	Freq	No	Freq	No	Freq	No	Freq	No	Freq	No	Freq
Pisces	1	52	1	60	1	79	1	46	2	50	1	56
Cypriniformes									1	5	1	2
Notemigonus crysoleucas									1	3	1	1
Cyprinidae									1	3	1	1
Atheriniformes	1	29	1	10	1	17	1	11	2	27	2	20
Fundulus chrysotus					1	4					1	1
Lucania goodei	1	14			1	8	1	3	1	5	1	6
Gambusia affinis	2	14	1	10	1	4	1	5	2	23	2	12
Heterandria formosa							1	3			1	1
Perciformes	1	5	1	30	1	17			1	3	1	7
Lepomis gulosus					1	4					1	1
Lepomis macrochirus	1	5	1	10	1	8					1	3
Micropterus salmoides					1	4					1	1
Centrarchidae			3	10					1	3	1	2
Etheostoma fusiforme			1	20							1	2
Remains	1	19	2	20	2	50	1	35	1	17	1	29
Crustacea	1	38	4	40	2	25	25	35	1	27	9	32
Cladocera			3	10			5	5			4	2
Eucopepoda							300	3			60	1
Amphipoda	1	9	2	10			1	5	1	3	1	5
Decapoda	2	29	2	30	2	25	1	22	1	25	1	25
Insecta	5	29	8	30	1	4	3	30	1	22	3	23
Hemiptera	2	24	1	10	1	4	2	13	1	13	1	13
Odonata	5	9	2	10			1	11	1	5	2	7
Diptera	7	5	6	30			2	16			4	8
Ephemeroptera	1	8	1	20			2	3	1	3	1	5
Trichoptera	1	5							1	5	1	2

Table 62. Continued

	Habitat										Lake Average	
	Maidencane		Maidencane-hydrilla		Spatterdock		Spatterdock-hydrilla		Hydrilla			
Taxon	No	Freq	No	Freq	No	Freq	No	Freq	No	Freq	No	Freq
Number of stomachs containing food	21		10		24		37		40		132	

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[a] Mean number of a taxon per stomach was calculated by dividing the total number of individuals of the taxon by the number of stomachs containing that taxon.

Fish and crustaceans were eaten with highest frequency by largemouth bass <300 mm in Lake Henderson (Table 63). In the maidencane habitat, grass shrimp were the dominant forage organism followed by mosquitofish. Frequency of full stomachs was highest in the maidencane habitat. In the spatterdock habitat, crustaceans, mainly grass shrimp, were the principal food in subharvestable bass diets. Fish were a secondary forage item with several species being eaten only infrequently. Only two subharvestable bass were collected in the open water habitat, limiting analysis of their diets.

Comparing the diets of largemouth bass <300 mm from Orange Lake with those in Lake Henderson revealed a much higher frequency of grass shrimp in the diets of Lake Henderson largemouth bass than in Orange Lake fish. On the other hand, subharvestable bass in Orange Lake consumed more fish. The prominent species of fish consumed in both lakes were mosquitofish and bluefin killifish. Bluefin killifish and bluegill were eaten more frequently in both the maidencane and spatterdock habitats in Orange Lake. Mosquitofish were more frequently eaten in the Lake Henderson maidencane and spatterdock habitats. Insects, primarily hemipterans, were consumed more frequently in Orange Lake habitats. Frequency of full stomachs was higher in the vegetated habitats in Lake Henderson than in Orange Lake.

Previous research has shown largemouth bass <300 mm fed primarily on fish, crustaceans and insects (Shireman et al. 1983, Mullan and Applegate 1968, Emig 1966b). Small largemouth bass in Orange Lake consumed a wide variety of foods from each of those categories, but showed a preference for small fish over crustaceans and insects. Despite their preference for small fish, the relative vulnerability of prey items may have influenced the diet of small largemouth bass in Orange Lake. Evidence of this is seen when comparing habitats. The highest frequency of fish and the

Table 63. Annual mean number of organisms per stomach[a] (no) and frequency of occurrence (freq, %) of food items consumed by <300 mm TL largemouth bass, Lake Henderson, October 1982-August 1983.

	Habitat						Lake Average	
	Maidencane		Spatterdock		Open water			
Taxon	No	Freq	No	Freq	No	Freq	No	Freq
Pisces	2	45	1	45	1	50	2	45
Clupeiformes			1	2			1	1
Dorosoma cepedianum			1	2			1	1
Atheriniformes	3	22	1	9			3	16
Lucania goodei	3	5	1	5			2	5
Gambusia affinis	2	20	1	5			2	13
Labidesthes sicculus	2	2					2	1
Perciformes	1	7	1	9	1	50	1	9
Enneacanthus gloriosus			1	2			1	1
Lepomis gulosus	1	2					1	1
Lepomis machrochirus	1	2	1	5			1	3
Lepomis punctatus	2	2					2	1
Micropterus salmoides					1	50	1	1
Centrarchidae			1	2			1	1
Etheostoma fusiforme	1	2					1	1
Remains	1	17	1	24			1	19
Crustacea	4	43	5	50			5	45
Cladocera			2	2			2	1
Decapoda	4	43	5	48			5	44
Insecta	2	7	1	7	1	50	2	8
Hemiptera	1	2					1	1
Odonata	1	2	1	5	1	50	1	4
Diptera	3	3	2	2			3	3
Number of stomachs containing food		60		42		2		104

[a] Mean number of a taxon per stomach was calculated by dividing the total number of individuals of the taxon by the number of stomachs containing that taxon.

lowest frequency of insects in the diet occurred in the spatterdock habitat, even though there was a relatively low abundance of small (<80 mm) forage fish and a high abundance of insects present in this habitat. Further, frequency of full stomachs was highest in the spatterdock habitat. This would be in agreement with findings of Savino and Stein (1982) who noted that prey vulnerability decreased as habitat complexity increased. The increased consumption of insects in the other habitats resulted from the lower vulnerability of forage fish.

Small largemouth bass in Lake Henderson consumed fish and crustaceans with approximately equal frequency in all habitats. The higher incidence of grass shrimp in the diet of largemouth bass in Lake Henderson as compared with Orange Lake is reflective of the greater abundance of these crustaceans in both the maidencane and spatterdock habitats of Lake Henderson. The equal frequency of fish and crustaceans in the diet would also suggest decreased vulnerability of forage fish. Alternatively, the low frequency of fish in the diet of small largemouth bass in Lake Henderson may reflect the low abundance of small forage fish in the habitats of this lake as evidenced by the lower F/P ratios. The similar condition factors of small bass in the two lakes indicates forage value of grass shrimp is similar to forage value of fish. If this is the case, grass shrimp may be a valuable alternate forage. The higher frequency of crustaceans than insects in the diet reflects a greater vulnerability of these invertebrates. The greater frequency of atheriniform fish in the diet in the maidencane habitat parallels their greater abundance in this habitat than in the spatterdock habitat.

Largemouth Bass $\geq$ 300 mm TL

Major food items in the diets of largemouth bass >300 mm TL in Orange Lake were fish and grass shrimp (Table 64). The species occurring most often were golden shiners, bluegills and unidentifiable centrarchids. No one species

Table 64. Annual mean number of organisms per stomach[a] (no) and frequency of occurrence (freq, %) of food items consumed by $\geq$300 mm TL largemouth bass, Orange Lake, October 1982-August 1983.

	Habitat											
	Maidencane		Maidencane-hydrilla		Spatterdock		Spatterdock-hydrilla		Hydrilla		Lake Average	
Taxon	No	Freq	No	Freq	No	Freq	No	Freq	No	Freq	No	Freq
Pisces	1	57[b]	1	63	1	78	1	41	2	71	1	51
Cypriniformes	1	14	2	6			1	7			1	7
Notemigonus crysoleucas	1	14	2	6			1	7			1	7
Atheriniformes			1	6			1	3			1	3
Gambusia affinis							1	3			1	1
Poecilia latipinna			1	6							1	1
Perciformes	1	7	2	19			1	3	2	29	2	9
Enneacanthus gloriosus			1	6							1	1
Lepomis macrochirus	1	7	1	6					2	14	1	4
Lepomis							1	3			1	1
Centrarchidae			3	6					2	14	3	3
Remains	1	36	1	31	1	78	1	31	1	43	1	33
Crustacea	7	21	3	37	7	33	3	38	9	43	5	35
Decapoda	7	21	3	37	7	33	3	38	9	43	5	35
Insecta							1	7			1	3
Odonata							1	7			1	3
Number of stomach containing food		14		16		9		29		7		75

[a] Mean number of a taxon per stomach was calculated by dividing the total number of individuals of the taxon by the number of stomachs containing that taxon.

[b] Column total does not equal or exceed 100% due to collection of two largemouth bass with unidentifiable remains in their stomachs.

of fish was consumed with notably higher frequency in any habitat. Grass shrimp were consumed with regularity in all habitats, occurring most frequently in the diet of largemouth bass in the hydrilla habitat. Frequency of full stomachs was highest in the hydrilla habitat (Table 58).

Fish were the major food item in the diets of largemouth bass >300 mm TL in Lake Henderson (Table 65). In the maidencane habitat, largemouth bass ate primarily fish. A wide diversity of fish was eaten. Grass shrimp and gizzard shad were the prominent food items in the spatterdock habitat. Gizzard shad were also the most frequently eaten organism in the open water. Frequency of full stomachs was highest in the open water habitats (Table 58).

Comparisons of the two lakes showed grass shrimp, bluegills and golden shiners were more frequently consumed in Orange Lake. Gizzard shad, threadfin shad and lake chubsuckers were consumed more often in Lake Henderson. Frequency of full stomachs was higher in Lake Henderson.

It is well documented that adult largemouth bass feed primarily on fish (Emig 1966b, Heidinger 1975, Carlander 1977). Fish were also the dominant forage of large largemouth bass in Orange Lake. No one species of fish was selected above the other, but perciforms and cyprinids (golden shiners) were preferred over small forage fish, such as atheriniforms. All fish consumed were species that are characteristically closely associated with aquatic vegetation. Roughly one third of the largemouth bass ≥ 300 mm collected in Orange Lake had grass shrimp in their diets. This frequency is approximately equal to that found in small largemouth bass diets suggesting that the importance of grass shrimp as a forage for largemouth bass in Orange Lake is unaffected by bass size.

Adult largemouth bass in Lake Henderson showed almost complete dependence on fish as forage. Lake Henderson bass

Table 65. Annual mean number of organisms per stomach^a (no) and frequency of occurrence (freq, %) of food items consumed by ≥300 mm TL largemouth bass, Lake Henderson, October 1982-August 1983.

	Habitat						Lake Average	
	Maidencane		Spatterdock		Open water			
Taxon	No	Freq	No	Freq	No	Freq	No	Freq
Pisces	1	65	2	48	1	70	1	59
Clupeiformes	1	13	3	10	2	30	2	14
Dorosoma cepedianum	1	5	3	10	2	30	2	10
Dorosoma petenense	1	7					1	4
Cypriniformes	1	13	1	3	1	10	1	9
Notemigonus crysoleucas	1	5			1	10	1	4
Notropis maculatus	1	3					1	1
Erimyzon sucetta	1	5	1	3			1	4
Atheriniformes	1	3					1	1
Fundulus chrysotus	1	3					1	1
Perciformes	2	13	1	14			1	11
Lepomis gulosus			1	7			1	3
Lepomis machrochirus	1	3					1	1
Lepomis marginatus	1	3					1	1
Lepomis punctatus	1	3					1	1
Micropterus salmoides	3	5					3	3
Centrarchidae			1	7			1	3
Remains	1	27	1	24	1	40	1	28
Crustacea	7	5	8	21	1	10	7	11
Decapoda	7	5	8	21	1	10	7	11
Number of stomachs containing food		40		29		10		79

[a] Mean number of a taxon per stomach was calculated by dividing the total number of individuals of the taxon by the number of stomachs containing that taxon.

tended to utilize a wider variety of forage fish than bass in Orange Lake. The most notable difference was the consumption of open water clupeids in Lake Henderson. The common occurrence of shad in the diet suggests that some bass left the vegetation to forage in open water and returned to the vegetation when they were not actively feeding. The higher incidence of golden shiners and lake chubsuckers in bass diets in the maidencane habitat in Lake Henderson as compared to the spatterdock parallels the high abundance of these fish in the maidencane habitat.

In general, largemouth bass in Orange Lake and Lake Henderson were opportunistic feeders tending to eat prey that was vulnerable due to its abundance or lack of escape cover. The higher condition factor and frequency of full stomachs for largemouth bass ≥ 300 mm TL in Lake Henderson suggests a better forage resource. Fish, the dominant food item of Lake Henderson largemouth bass, were relatively less abundant in Lake Henderson. Forage fish, although less abundant, were more vulnerable due to less submergent vegetation in Lake Henderson. Conversely, in Orange Lake, the abundant forage fish were less vulnerable and, therefore, less frequently consumed. Fish were preferred over other types of forage; but, as noted by Lewis and Helms (1964), largemouth bass readily utilized less desirable food items when vulnerability of forage fish was low.

Chain Pickerel <300 mm TL

Fish were the predominant food of chain pickerel <300 mm TL in Orange Lake (Table 66). Species of fish occurring most frequently in the diet were bluefin killifish and bluegill. Analysis of food habits of of chain pickerel was limited due to the small sample sizes collected at each habitat.

No chain pickerel <300 mm were collected in Lake Henderson.

Table 66. Annual mean number of organisms per stomach[a] (no) and frequency of occurrence (freq, %) of food items consumed by <300 mm TL chain pickerel, Orange Lake, October 1982-August 1983.

	Habitat											
	Maidencane		Maidencane-hydrilla		Spatterdock		Spatterdock-hydrilla		Hydrilla		Lake Average	
Taxon	No	Freq	No	Freq	No	Freq	No	Freq	No	Freq	No	Freq
Pisces	1	100	1	100			1	100			1	100
Atheriniformes	1	50					2	67			2	50
Fundulus chrysotus	1	50									1	10
Lucania goodei							2	50			2	30
Poecilia latipinna							1	17			1	10
Perciformes	1	50	1	100			1	17			1	40
Lepomis macrochirus	1	50	1	50							1	20
Pomoxis nigromaculatus			1	50							1	10
Centrarchidae							1	17			1	10
Etheostoma fusiforme			1	50							1	10
Remains							1	17			1	10
Crustacea			1	50			1	17			1	20
Decapoda			1	50			1	17			1	20
Number of stomachs containing food		2		2		0		6		0		10

[a] Mean number of a taxon per stomach was calculated by dividing the total number of individuals of the taxon by the number of stomachs containing that taxon.

As reported by Scott and Crossman (1973) and Guillory (1979) the dominant forage of small chain pickerel in Orange Lake was fish, primarily atheriniforms and small perciforms. The wide variety of forage items eaten in low numbers reflects the opportunistic feeding habits of small chain pickerel. All food items in their diet are strongly associated with aquatic vegetation, suggesting that open water habitats or those with little vegetation are not important foraging habitats for small pickerel.

Chain Pickerel ≥ 300 mm TL

Chain pickerel ≥ 300 mm TL in Orange Lake fed almost exclusively on fish (Table 67). Bluegills and golden shiners were eaten most frequently. In the maidencane habitat, centrarchids, primarily bluegills and other *Lepomis* were consumed most frequently. In the maidencane-hydrilla habitat, bluegill, unidentified *Lepomis*, and golden shiners were main forage items. Only two chain pickerel >300 mm were collected from the spatterdock habitat. These fish ate bluegills, swamp darters, and grass shrimp. Bluegills, golden shiners, bluefin killifish and grass shrimp were eaten most frequently in the spatterdock-hydrilla habitat. Frequency of full stomachs was highest in this habitat (Table 58). Several species of fish were consumed with equal frequency in the hydrilla habitat.

Only four chain pickerel ≥ 300 mm TL with food in their stomachs were collected in Lake Henderson. Food habit analysis was not performed.

The diet of large chain pickerel in Orange Lake was similar to that of small chain pickerel with the exception that an even wider variety of fish were eaten. Preferred prey items (sunfish, golden shiners) for large chain pickerel in Orange Lake tended to be larger than those of the small chain pickerel agreeing, with Scott and Crossman (1973) and Guillory (1979). Again, all food items were species typically associated with aquatic vegetation,

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Table 67. Annual mean number of organisms per stomach[a] (no) and frequency of occurrence (freq, %) of food items consumed by ≥300 mm TL chain pickerel, Orange Lake, October 1982-August 1983.

	Habitat											
	Maidencane		Maidencane-hydrilla		Spatterdock		Spatterdock-hydrilla		Hydrilla		Lake Average	
Taxon	No	Freq	No	Freq	No	Freq	No	Freq	No	Freq	No	Freq
Pisces	1	73	1	100	1	100	1	83	2	75	1	81
Salmoniformes	1	7									1	2
Esox niger	1	7									1	2
Cypriniformes	1	7	1	50			1	17	1	25	1	16
Notemigonus crysoleucas	1	7	1	25			1	17	1	25	1	14
Notropis maculatus			1	25							1	2
Atheriniformes							2	17	1	25	1	9
Fundulus chrysotus							2	5	1	25	1	5
Lucania goodei							1	11			1	5
Perciformes	1	47	1	50	1	100	1	39	1	50	1	47
Enneacanthus gloriosus	1	7					3	5			2	5
Lepomis macrochirus	1	13	1	25	1	50	1	22	1	25	1	19
Lepomis	1	13	1	25					1	25	1	9
Micropterus salmoides							1	5			1	5
Pomoxis nigromaculatus							1	5			1	2
Centrarchidae	1	20					1	5			1	9
Etheostoma fusiforme					1	50					1	2
Remains	1	20					1	11	1	25	1	14
Crustacea					3	50	4	11			4	7
Decapoda					3	50	4	11			4	7
Number of stomachs containing food		15		4		2		18		4		43

[a] Mean number of a taxon per stomach was calculated by dividing the total number of individuals of the taxon by the number of stomachs containing that taxon.

reflecting the importance of aquatic plants to chain pickerel foraging behavior. This would explain the scarcity of chain pickerel in the habitats sampled in Lake Henderson.

SYSTEM INTERACTIONS

To further examine system interactions, correlation analyses (PROC CORR, SAS Institute 1982) were conducted for annual mean values of major biological parameters measured at 18 stations in Orange Lake and 9 stations in Lake Henderson.

Several investigators have found inverse relationships between phytoplankton abundance and macrophyte abundance (e.g., Kofoid 1903, Hasler and Jones 1949, Hogetsu et al. 1960, Goulder 1969, Dokulil 1973). The predominant explanation for this inverse relationship is nutrient competition between the macrophytes and algae (Embody 1928, Wiebe 1934, Fitzgerald 1969, Landers 1982). Our results show a significant inverse relationship between phytoplankton density (cells/liter) and macrophyte plant biomass (Table 68). This relationship has been discussed previously. However, an additional comparison is the relationship between phytoplankton biomass (mg chlorophyll a) and macrophyte biomass. Correlation analysis of data from both lakes combined showed no significant relationship between plant biomass and phytoplankton biomass. Further, no significant relationships between plant biomass and phytoplankton biomass were found for Orange Lake (r=0.32, p=0.19) or Lake Henderson (r=-0.31, p=0.41). These relationships between plant biomass and phytoplankton biomass do not support an inverse relationship between phytoplankton biomass and macrophyte biomass. There is clearly a discrepancy in the relationships between macrophyte biomass and phytoplankton cell count and between macrophyte biomass and phytoplankton biomass. Our data does not allow resolution of the problem.

Periphyton biomass was positively related to plant biomass (Table 68). Periphyton biomass showed no significant relationship to phytoplankton biomass for both lakes combined. Analyses of data for individual lakes revealed a positive relationship between phytoplankton

Table 68. Correlation of parameters measured in Orange Lake and Lake Henderson, October 1982-August 1983; r=correlation coefficient, p=probability of significant correlation, n=number of samples.

		Plant biomass (kg wet wt/m^2)	Stem density (no/m^2)	Phytoplankton biomass (mg chl a/liter)	Phytoplankton density (cells/liter)	Periphyton biomass (mg chl a/m^2)	Total zooplankton density (individuals/liter)	Rotifer density (individuals/liter)	Cladocera density (individuals/liter)	Eucopepoda density (individuals/liter)	Nauplii density (individuals/liter)	Epiphytic macroinvertebrate density (individuals/m^2)	Epiphytic macroinvertebrate biomass (mg dry wt/m^2)	Hydrosoil macroinvertebrate density (individuals/m^2)	Hydrosoil macroinvertebrate biomass (mg dry wt/m^2)	Fish density (individuals/ha)	Fish biomass (kg fresh wt/ha)
Plant biomass (kg wet wt/m^2)	r	1.00	0.34	0.08	–0.44	0.80	–0.46	–0.54	–0.44	0.14	–0.03	0.72	0.74	–0.24	0.15	0.56	0.57
	p	0.00	0.17	0.69	0.02	<0.01	0.01	<0.01	0.02	0.48	0.87	<0.01	<0.01	0.23	0.47	<0.01	<0.01
	n	27	18	27	27	27	27	27	27	27	27	27	27	27	27	27	27
Stem density (stems/m^2)	r		1.00	–0.21	0.60	0.05	–0.43	–0.45	0.08	–0.36	–0.14	0.65	0.76	–0.51	0.29	0.38	0.85
	p		0.00	0.41	<0.01	0.83	0.07	0.06	0.76	0.14	0.57	<0.01	<0.01	0.03	0.24	0.12	<0.01
	n		18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
Phytoplankton biomass (mg chl a/liter)	r			1.00	–0.16	0.37	0.11	0.00	–0.16	0.43	0.19	0.10	0.03	0.15	–0.13	0.12	–0.20
	p			0.00	0.42	0.06	0.60	0.99	0.42	0.03	0.35	0.63	0.86	0.46	0.51	0.36	0.31
	n			27	27	27	27	27	27	27	27	27	27	27	27	27	27
Phytoplankton density (cells/liter)	r				1.00	–0.48	–0.04	–0.03	0.37	–0.47	–0.01	–0.11	–0.08	0.05	0.31	–0.25	0.11
	p				0.00	0.01	0.84	0.87	0.05	0.02	0.95	0.58	0.68	0.81	0.12	0.20	0.60
	n				27	27	27	27	27	27	27	27	27	27	27	27	27
Periphyton biomass (mg chl a/m^2)	r					1.00	–0.46	–0.56	–0.57	0.20	–0.06	0.50	0.54	–0.02	–0.20	0.32	0.39
	p					0.00	0.01	<0.01	<0.01	0.31	0.78	<0.01	<0.01	0.93	0.32	0.11	0.05
	n					27	27	27	27	27	27	27	27	27	27	27	27
Total zooplankton density (individuals/liter)	r						1.00	0.89	0.67	0.44	0.47	–0.50	–0.53	0.26	–0.25	–0.15	–0.57
	p						0.00	<0.01	<0.01	0.02	0.01	<0.01	<0.01	0.19	0.21	0.45	<0.01
	n						27	27	27	27	27	27	27	27	27	27	27
Rotifera density (individuals/liter)	r							1.00	0.51	0.22	0.06	–0.47	–0.54	0.28	–0.18	–0.14	–0.53
	p							0.00	<0.01	0.28	0.75	0.01	<0.01	0.15	0.36	0.47	<0.01
								27	27	27	27	27	27	27	27	27	27
Cladocera density (individuals/liter)	r								1.00	0.14	0.29	–0.38	–0.34	0.02	–0.01	–0.17	–0.24
	p								0.00	0.47	0.14	0.05	0.08	0.93	0.98	0.40	0.23
	n								27	27	27	27	27	27	27	27	27
Eucopepoda density (individuals/liter)	r									1.00	0.27	–0.10	–0.08	0.12	–0.30	0.31	–0.26
	p									0.00	0.18	0.62	0.68	0.55	0.13	0.11	0.19
	n									27	27	27	27	27	27	27	27
Nauplii density (individuals/liter)	r										1.00	–0.20	–0.17	0.08	–0.20	–0.21	–0.29
	p										0.00	0.32	0.39	0.19	0.32	0.29	0.15
	n										27	27	27	27	27	27	27
Epiphytic macroinvertebrate density (individuals/m^2)	r											1.00	0.95	–0.22	0.27	0.57	0.81
	p											0.00	<0.01	0.28	0.17	<0.01	<0.01
	n											27	27	27	27	27	27
Epiphytic macroinvertebrate biomass (mg dry wt/m^2)	r												1.00	–0.26	0.29	0.61	0.91
	p												0.00	0.19	0.14	<0.01	<0.01
	n												27	27	27	27	27
Hydrosoil macroinvertebrate density (individuals/m^2)	r													1.00	0.06	–0.01	–0.21
	p													0.00	0.75	0.98	0.29
	n													27	27	27	27
Hydrosoil macroinvertebrate biomass (mg dry wt/m^2)	r														1.00	0.22	0.41
	p														0.00	0.28	0.04
	n														27	27	27
Fish density (individuals/ha)	r															1.00	0.48
	p															0.00	0.01
	n															27	27
Fish biomass (gm fresh wt/ha)	r																1.00
	p																0.00
	n																27

biomass and periphyton biomass in Orange Lake (r=0.51, p=0.03) but no significant relationship in Lake Henderson (r=-0.22, p=0.58). Partial correlation analysis (McNemar 1969) showed a negative relationship (r=-0.39, p<0.025) between phytoplankton biomass and macrophyte biomass when periphyton biomass was held constant for both lakes combined. The same partial correlation analyses revealed nonsignificant relationships for individual lakes (Orange Lake, r=-0.18, p $\geq$ 0.05; Lake Henderson, r=-0.28, p>0.05). Partial correlation between periphyton biomass and phytoplankton biomass with plant biomass held constant resulted in a significant positive relationship (r=0.51, p<0.01) for data from both lakes combined. The same partial correlation analyses for individual lakes revealed a significant positive relationship in Orange Lake (r=0.46, p<0.05) but no significant relationship in Lake Henderson (r=0.21, p>0.05).

A possible explanation of these results requires consideration of the types of macrophytes comprising plant biomass. Emergent plants were a large component of plant biomass in all but the hydrilla habitat. The emergent plants supported relatively low biomass of periphyton. Submergent macrophytes supported a higher biomass of periphyton and were more abundant in Orange Lake. Orange Lake had higher nutrient levels and phytoplankton biomass. If the higher nutrient levels in Orange Lake facilitated both submergent macrophyte growth and phytoplankton growth, an inverse relationship between macrophyte biomass and phytoplankton biomass would decrease (i.e., be less negative). Further since submergent macrophytes largely affected the periphtyon biomass, a positive relationship between periphyton biomass and phytoplankton biomass would be expected. Although Allen (1973) has shown utilization by periphyton of dissolved nutrients produced by the host plant, it is likely that higher levels of inorganic nutrients increase periphyton biomass. This proposed explanation suggests a possbile interaction between submergent and emergent macrophytes, such that high biomass of emergent macrophytes may, via nutrient uptake, competitively inhibit submergent macrophytes. Similarly, floating macrophytes may compete with submergent macrophytes. Clearly, this subject requries additional investigation.

Numerous investigators (e.g., Reighard 1915; Baker 1918; Needham 1929, 1938; Surber 1930; Rosine 1955; Krull 1970; Soska 1975; Dvorak and Best 1982) have found increased macroinvertebrate abundance when macrophytes were present. In Orange Lake and Lake Henderson, epiphytic macroinvertebrate density and biomass were positively related to plant biomass (Table 68). In addition to providing substrate for the macroinvertebrates, the macrophytes provide a food source. Most of the epiphytic macroinvertebrates are herbivorous or omnivorous, including amphipods, decapods, mayfly (Ephemeroptera) naiads, caddisfly (Trichoptera) larvae, lepidoptera larvae, some beetle (Coleoptera) larvae and adults, some diptera larvae, and gastropods (Pennak 1978, Edmondson 1959, Wetzel 1975). Food for these taxa is provided by the living macrophytes, especially the more succulent taxa such as *Utricularia* and *Cabomba*, and by the detritus from dead tissue. In addition, the macrophytes provide substrate for periphyton. The importance of periphyton to epiphytic macroinvertebrates has been discussed earlier and is supported by significant positive relationships between periphyton biomass and epiphytic macroinvertebrate density and between periphyton biomass and epiphytic macroinvertebrate biomass. The partial correlation between epiphytic macroinvertebrate biomass and periphyton biomass with plant biomass held constant was, however, not significant ($r=-0.14$, $p>0.05$). Similarly, the partial correlation between epiphytic macroinvertebrate density and periphyton biomass held constant was not significant ($r=-0.18$, $p>0.05$). These results suggest the subtrate or protection from predation functions of macrophytes are more important determinants of

the epiphytic macroinvertebrate abundance than the role of macrophytes as a substrate for periphyton. The lack of significant correlation between hydrosoil macroinvertebrate abundance and plant biomass suggests density and biomass of hydrosoil macroinvertebrates were not affected by macrophytes. Hence, the epiphytic macroinvertebrate community was an addition to the aquatic ecosystem, rather than a replacement for the hydrosoil fauna.

We have shown earlier the importance of abundant macrophytes as habitat for fish. There were positive correlations between fish density and plant biomass and fish biomass and plant biomass. However, partial correlations between fish density and plant biomass with epiphytic macroinvertebrate density held constant showed a lower positive correlation ($r=-0.26$, $p<0.05$) and fish biomass was negatively related to plant biomass when epiphytic macroinvertebrate density was held constant ($r=-0.35$, $p<0.05$). On the other hand, partial correlation analyses showed positive relationships between fish density and epiphytic macroinvertebrate density ($r=0.35$, $p<0.05$) and between fish biomass and epiphytic macroinvertebrate biomass ($r=0.88$, $p<0.05$) when plant biomass was held constant. These results suggest the relationships between fish abundance and total plant biomass are largely due to the food resource provided by the macrophytes rather than a preference for abundant macrophytic vegetation. Fish biomass was positively related to stem density (Table 68), a measure of the abundance of emergent vegetation (primarily *Panicum*, *Paspalidium*, *and* and *Nuphar*). Partial correlation between fish biomass and stem density with epiphytic macroinvertebrate biomass held constant also showed a positive relationship ($r=0.60$, $p<0.05$). These results indicate a preference for dense emergent macrophytic vegetation independent of the food resource provided by the macrophytes. Because fish biomass is more sensitive to changes in abundance of larger fish than small fish, the positive relationship between fish biomass and stem density and the nonsignificant correlation between fish density and stem density suggests dense emergent macrophytes are a desirable habitat for larger fish. Overall, these results suggest emergent plants provide desirable fish habitat and floating and submergent plants provide, via the macroinvertebrates they support, a valuable food resource.

Analyses of bluegill food habits showed some zooplankton were eaten by bluegills, but larger invertebrates were more frequent in their diets. Other fish species collected in our study lakes known to consume both zooplankton and various macroinvertebrates include golden shiner (Keast and Webb 1966, Scott and Crossman 1973), lake chubsucker (Scott and Crossman 1973), brook silverside (Keast and Webb 1966, Scott and Crossman 1973), mosquitofish (Lee et al. 1980), bluespotted sunfish (Lee et al. 1980), redear sunfish (Lee et al. 1980, Wilbur 1969), and black crappie (Keast 1968). Although zooplankton is an important food resource to many of the fish collected in Orange Lake and Lake Henderson, fish biomass was negatively related to total zooplankton density. Zooplankton density was also inversely related to plant biomass. As discussed above, fish were most abundant in heavily vegetated habitats where alternate foods were available. These results suggest the need for food preference studies of zooplankton/benthic feeding fish and comparative evaluations of the energetic value of zooplankton and epiphytic invertebrate food resources.

CONCLUSIONS

1. Measured water quality parameters indicated Orange Lake and Lake Henderson were eutrophic. Water quality parameters and phytoplankton and zooplankton communities suggested more eutrophic conditions in Orange Lake.

2. Differences in measured water quality parameters were not related to differences in abundance and composition of aquatic plant communities (habitats).

3. The macrophytes studied supported abundant periphyton. Periphyton biomass was not significantly different among habitat types; however, periphyton biomass differed among macrophytes. Periphyton biomass was highest on submergent macrophytes, intermediate on floating macrophytes, and lowest on emergent macrophytes. Periphyton biomass was related to surface area per unit weight of the host macrophytes. Other factors likely affecting periphyton abundance included season, age of host macrophytes, and nutrient availability.

4. Phytoplankton density (cells/liter) was inversely related to macrophyte biomass. Phytoplankton biomass was, however, not related to macrophyte biomass. Our data did not provide sufficient information to explain this discrepancy.

5. Zooplankton density was inversely related to macrophyte biomass.

6. Hydrosoil macroinvertebrate density and biomass were not significantly related to plant biomass; however, there were significant differences among macrophyte communities. Hydrosoil macroinvertebrate density and biomass were high in habitats with moderate densities of emergent macrophytes. Hydrosoil macroinvertebrate densities were low in habitats with soft, unstable

hydrosoil and habitats with extensive volume of emergent macrophyte roots.

7. Epiphytic macroinvertebrate density and biomass were positively related to plant biomass and were significantly different among habitat types. Epiphytic macroinvertebrate abundance was highest on floating macrophytes, intermediate on submergent macrophytes, and lowest on emergent macrophytes. Differences in epiphytic macroinvertebrate density and biomass among habitats were related to the abundance of different macrophytes in the different habitats.

8. Of the 22 species of fish collected, only eight exhibited habitat preferences: Florida gar preferred spatterdock and hydrilla habitats; gizzard shad, threadfin shad, and taillight shiner preferred the open water habitat; brook silversides preferred maidencane habitats; bluegills preferred habitats containing hydrilla and dense maidencane habitats; redear sunfish $\geq$ 160 mm TL preferred the open water-macrophyte ecotone; and black crappie preferred the open water habitat and the open water-hydrilla ecotone. The remaining species collected exhibited no preference for a specific habitat type, but rather were collected in habitats with abundant macrophytes.

9. Fish distribution was affected by epiphytic macroinvertebrate abundance. Food habit analyses supported the importance of epiphytic macroinvertebrates as a food resource.

10. Based on the macrophyte communities sampled, the most desirable habitats for bluegills, largemouth bass and chain pickerel would contain dense emergent vegetation interspersed with patches of submersed and floating macrophytes.

RECOMMENDATIONS FOR FUTURE RESEARCH

1. Additional aquatic plant communities should be studied. Our present results support recognition of three distinct categories of aquatic plants: emergent, submergent, and floating. Ecological value of aquatic plants was related to these categories more so than to particular species. If ecologically valid, recognition of these categories of aquatic plants would simplify ecosystem assessment and formulation of aquatic plant management plans. Further study of additional aquatic plant communities are necessary to validate the soundness of this categorization. Quantiative and qualitative aspects of the plants in these categories affected aspects of ecosystem function. Additional investigations will also allow further assessment of quantitative and qualitative aspects of the plants in these three categories.

2. Future studies should be conducted for a minimum of two years. We found significant temporal variations in almost all analyses. Because much of this variation was likely due to endogenous seasonality, necessary replication requires multi-year investigations.

3. To increase the breadth of application of findings from this and similar studies, future study lakes should be representative of the wide range of trophic conditions occurring in Florida.

4. Food habits of additional fish species, especially forage fishes, should be quantified. We have demonstrated the importance of epiphytic macroinvertebrates as a food resource for several species of fish. The extent of the value of this food resource to other fishes requires consideration.

5. Seasonal fluctuations in epiphytic macroinvertebrates may significantly affect fish populations. This can be addressed in multi-year studies.

6. We found discrepant relationships between phytoplankton abundance and macrophyte biomass. Our results also demonstrated abundant periphyton associated with aquatic macrophytes. The planktonic and epiphytic algae may have significant effects on the aquatic ecosystem. Interrelationships between dissolved nutrients, phytoplankton, periphyton, macrophytes, and epiphytic macroinvertebrates require further investigation.

7. Future studies should consider changes in ecosystem components associated with experimental manipulations of aquatic plant communities. Proper selection and conduct of such manipulations will provide opportunities for validation of the findings from habitat comparison studies.

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APPENDIX A

EVALUATION OF PERIPHYTON REMOVAL EFFICIENCY

We compared the efficiency of three successive washes for periphyton removal for five prevalent macrophytes: Eichhornia (root system), Nuphar, Paspalidium, Hydrilla and Utricularia. Three replicate samples of each macrophyte were collected. Each sample consisted of approximately 100 g of plant material. Each sample was placed in 500 ml of tap water in 1-liter, widemouth Nalgene bottle, and placed on ice. Periphyton was removed by shaking within 7 hours of collection. Each sample was subjected to 20, 30-second shake treatments (washes). After each wash, the supernatant was poured through a 0.25 mm screen, 500 ml fresh tap water was added, and the sample shaken again until the 20 washes were completed. Chlorophyll a was measured for a subsample of the supernatant from each wash. Each macrophyte was dried for 24 hr at 60 C, weighed, and periphyton biomass (mg chlorophyll a /gm plant dry weight) calculated for each wash.

Total periphyton biomass (the sum of 20 washes) ranged from 0.0383 mg chlorophyll a /gm plant on Paspalidium to 1.644 mg chlorophyll a /gm plant on Hydrilla (Table A.1.). The rate of epiphyte removal per wash decreased similarly for all macrophytes (Figure A.1.). Regressions of logarithm transformed data (PROC GLM, SAS Institute 1982) of epiphyte biomass removed on wash number were also similar for the different macrophytes (Table A.2). This indicates a consistent proportion of epiphyte biomass was removed from each sample in

Table A.1. Comparison of periphyton chlorophyll a removed in three washes and 20 washes from macrophytes collected in Orange Lake.

Host macrophyte	Sample	Periphyton chlorophyll a removed in 3 washes (mg/gm dry weight plant)	Periphyton chlorophyll a removed in 20 washes (total periphyton) (mg/gm dry weight plant)	Percent of total removed in 3 washes
Eichhornia crassipes (root system)	1	0.2296	0.3450	66.5
	2	0.1784	0.2713	65.8
	3	0.2138	0.3318	64.4
Mean				65.6
Nuphar luteum	1	0.0364	0.0841	43.3
	2	0.0388	0.0855	45.4
	3	0.0748	0.1518	49.3
Mean				46.0
Paspalidium geminatum	1	0.0352	0.0496	71.0
	2	0.1064	0.1570	67.8
	3	0.0261	0.0383	68.1
Mean				69.0
Hydrilla verticillata	1	1.3070	1.6440	79.5
	2	1.1113	1.4773	75.2
	3	0.4347	0.6851	63.4
Mean				72.7
Utricularia sp.	1	1.0233	1.2498	81.9
	2	1.0868	1.4992	67.3
	3	0.8391	1.3605	61.7
Mean				70.2
Grand Mean		0.4494	0.6287	64.7
Coefficient of Variation		106	99	17

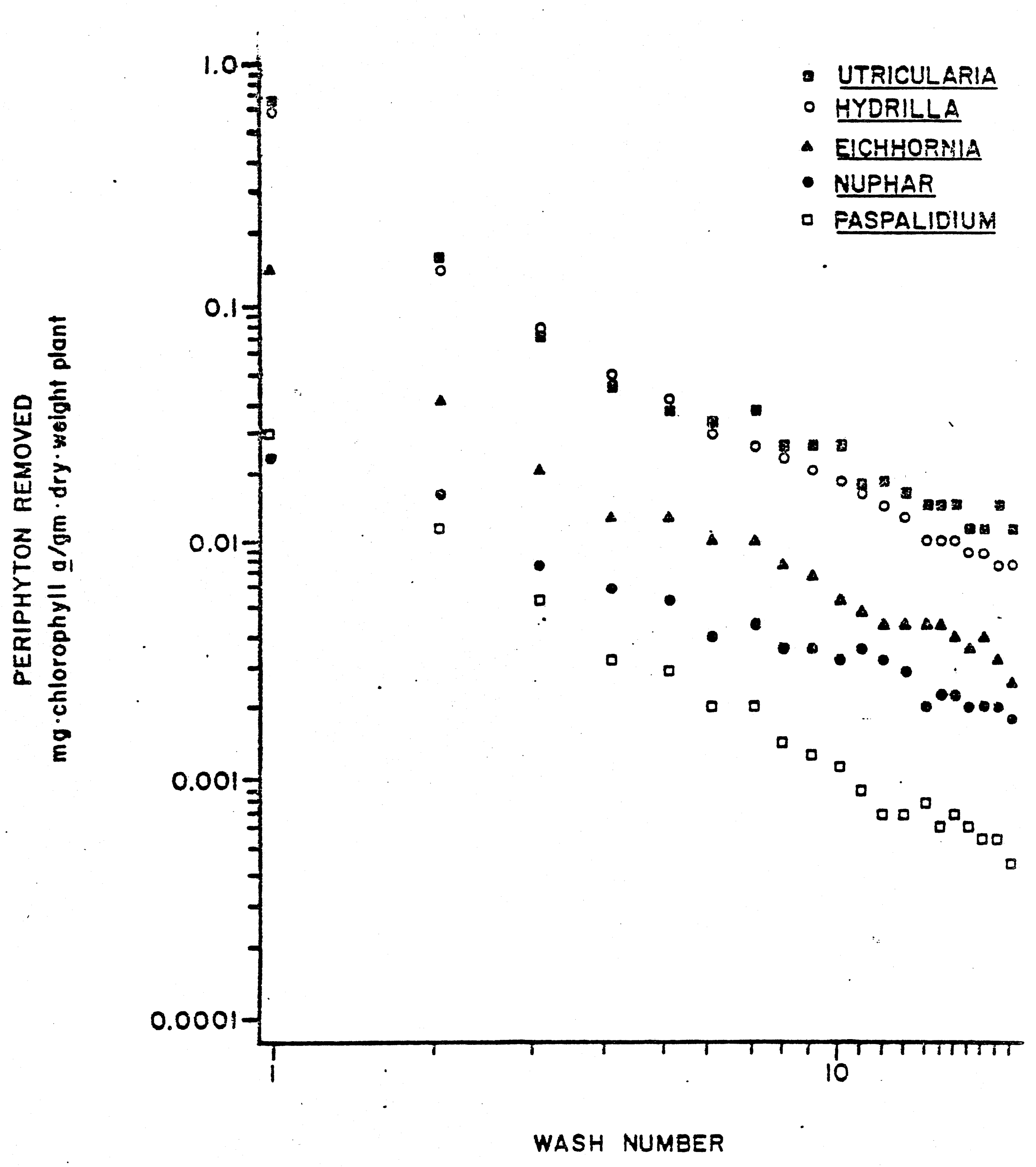

Figure A.1. Periphyton removal in successive washes from various macrophytes.

Table A.2. Results of regression analysis for periphyton removed (mg chlorophyll *a*/gm dry weight plant) in 20 sequential washes from macrophytes collected in Orange Lake using the equation:

$\log_{10}$(mg chlorophyll *a*/gm dry weight plant) = a + b($\log_{10}$ wash number).

		From Observed Periphyton Removed			Predicted Periphyton Removed		
Host Macrophyte	Sample	Intercept (a)	Slope (b)	R^2	After 3 washes	After 20 washes (total)	Percent of total after 3 washes
Eichhornia crassipes	1	-0.91	-1.30	0.97			
	2	-1.09	-1.17	0.96			
	3	-1.10	-1.04	0.88			
	Total	-1.03	-1.17	0.92	0.161	0.275	58
Nuphar luteum	1	-1.68	-0.91	0.90			
	2	-1.73	-0.84	0.88			
	3	-1.54	-0.79	0.86			
	Total	-1.65	-0.84	0.77	0.044	0.100	44
Paspalidium geminatum	1	-1.72	-1.37	0.98			
	2	-1.16	-1.43	0.98			
	3	-1.89	-1.26	0.97			
	Total	-1.59	-1.35	0.75	0.042	0.063	65
Hydrilla verticillata	1	-0.18	-1.53	0.96			
	2	-0.25	-1.44	0.98			
	3	-0.66	-1.19	0.98			
	Total	-0.38	-1.37	0.93	0.671	1.010	66
Utricularia sp.	1	-0.41	-1.44	0.93			
	2	-0.41	-1.20	0.88			
	3	-0.45	-1.07	0.90			
	Total	-0.42	-1.24	0.82	1.525	2.490	61

Appendix B. Common and scientific names of fishes[1] collected in Orange Lake and Lake Henderson, October 1982-August 1983.

Order	Scientific Name	Common Name
Semionotiformes	*Lepisosteus platyrhinchus*	Florida gar
Amiiformes	*Amia calva*	bowfin
Clupeiformes	*Dorosoma cepedianum*	gizzard shad
	Dorosoma petenense	threadfin shad
Salmoniformes	*Esox niger*	chain pickerel
Cypriniformes	*Notemigonus crysoleucas*	golden shiner
	Notropis maculatus	taillight shiner
	Erimyzon sucetta	lake chubsucker
Siluriformes	*Ictalurus nebulosus*	brown bullhead
Percopsiformes	*Aphredoderus sayanus*	pirate perch
Perciformes	*Morone chrysops*	white bass
	Morone saxatilis	striped bass
	Elassoma zonatum	banded pygmy sunfish
	Enneacanthus gloriosus	bluespotted sunfish
	Lepomis gulosus	warmouth
	Lepomis macrochirus	bluegill
	Lepomis marginatus	dollar sunfish
	Lepomis microlophus	redear sunfish
	Lepomis punctatus	spotted sunfish
	Micropterus salmoides	largemouth bass
	Pomoxis nigromaculatus	black crappie
	Etheostoma fusiforme	swamp darter

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[1] From Robins, et al. (1980).