Table 151. (Concluded)

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Open-water nets (n=3) for total fish				
Bowfin	4	4	0.2	0.21
Gizzard shad	226	23	65.3	7.96
Threadfin shad	23926	23253	49.4	48.44
Grass carp	0	0	0.0	0.00
Yellow bullhead	0	0	0.0	0.00
White catfish	49	26	0.1	0.06
Seminole killifish	12	12	0.0	0.02
Sailfin molly	0	0	0.0	0.00
Brook silverside	8	8	0.0	0.01
Bluespotted sunfish	0	0	0.0	0.00
Warmouth	33	33	0.5	0.50
Bluegill	321	203	13.3	6.89
Redear sunfish	301	236	30.0	23.12
Largemouth bass	342	73	6.7	2.68
Black crappie	0	0	0.0	0.00
Total	25223		165.5	
Open-water nets (n=3) for harvestable fish				
Yellow bullhead	0	0.0	0.0	0.00
White catfish	0	0.0	0.0	0.00
Warmouth	0	0.0	0.0	0.00
Bluegill	111	65.4	8.5	4.63
Redear sunfish	284	219.7	29.1	22.26
Largemouth bass	8	4.1	2.4	1.36
Black crappie	0	0.0	0.0	0.00
Total	403		40.0	

Table 152. Experimental gillnet (five 10-meter long sections of 1.9, 2.5, 3.8, 5.1, and 6.4 cm bar mesh, which were 2.4 meter deep) catch per unit effort estimates of total and harvestable fish number (number/net/24 hr) and weight (kg/net/24 hr) for Orienta. Mean values for experimental gillnets are listed by species with the corresponding standard error of the mean.

Common Name	Fish number (number/net/24 hr)	Standard Error	Fish weight (kg/net/24 hr)	Standard Error
Gillnets (n=3) for total fish				
Gizzard shad	26.0	5.03	8.9	2.18
Lake chubsucker	0.3	0.33	0.1	0.12
Yellow bullhead	0.3	0.33	0.1	0.07
Warmouth	0.3	0.33	0.0	0.02
Redear sunfish	0.7	0.67	0.0	0.02
Largemouth bass	3.3	1.86	1.3	0.48
Black crappie	0.3	0.33	0.3	0.26
Total	31.3		10.7	
Gjllnets (n=3) for harvestable fish				
Yellow bullhead	0.3	0.33	0.1	0.07
Warmouth	0.0	0.00	0.0	0.00
Redear sunfish	0.7	0.67	0.0	0.02
Largemouth bass	1.7	0.67	1.2	0.39
Black crappie	0.3	0.33	0.3	0.26
Total	3.0		1.5	

Table 153. Electrofishing catch per unit effort estimates of total and harvestable fish number (number/hr) and weight (kg/hr) for Orienta. Mean values are listed by species with the corresponding standard error of the mean.

Common Name	Number (number/hr)	Standard Error	Weight (kg/hr)	Standard Error
Electrofishing runs (n=5) for total fish				
Gizzard shad	3.6	2.40	1.0	0.70
Threadfin shad	518.4	518.40	0.3	0.30
White catfish	3.6	3.60	2.2	2.20
Brook silverside	1.2	1.20	0.0	0.00
Bluegill	81.6	25.80	3.1	1.00
Redear sunfish	25.2	7.90	1.9	0.60
Largemouth bass	33.6	4.50	13.8	2.90
Total	667.2		22.2	
Electrofishing runs (n=5) for harvestable fish				
White catfish	3.6	3.60	2.2	2.20
Bluegill	16.8	6.95	1.1	0.46
Redear sunfish	14.4	6.18	1.6	0.65
Largemouth bass	18.0	4.24	12.8	3.07
Total	52.8		17.7	

open-water species collected in the experimental gillnets were gizzard shad and largemouth bass with 26, and 3.3 fish/net/24 hr, respectively (Table 152). The most abundant species collected using electrofishing were threadfin shad and bluegill with catch per unit efforts of 520 and 82 fish per hour, respectively (Table 153). Average first year growth of bluegill, redear sunfish, and largemouth bass was 63, 72, and 158 mm TL, respectively (Table 6). Mark-recapture estimates indicated that there were 125 harvestable bluegill, 26 harvestable redear sunfish, and 37 harvestable largemouth bass per hectare in Lake Orienta (Table 7).

The fish population in Lake Orienta was sampled with blocknets three times between May 1979 and September 1980 (Osborne et al. 1982). The total fish biomass ranged 80 to 155 kg/Ha, which was less than the littoral values obtained by us (230 kg/ha; Table 151). We, however, captured more large gizzard shad (Table 151) than Osborne et al. (1982).

Conine

Location and Morphology

Conine is located in Polk County, Florida (Latitude 28.03 N; Longitude 81.43 N). The lake lies in the Winter Haven Karst division of the Central Lakes District (Brooks 1981). The geology is dominated by deeply weathered clayey sand and granular sands of the Hawthorne Formation. Conine was sampled from 1988 to 1989 and had a surface area, shoreline length, and mean depth of 96 ha, 3.60 km and 3.5 m, respectively (Table 1).

Trophic Status and Water Chemistry

Conine is a hypereutrophic lake. Conine had an average total phosphorus concentration of 1043 µg/L and an average total nitrogen concentration of 2056 µg/L during this study. Total chlorophyll *a* concentrations averaged 110 µg/L and the water clarity as measured by use of a Secchi disc averaged 0.5 meters (Table 2). The lake had an average pH of 8.1 and an average total alkalinity of 64 mg/L as $CaCO_3$. The average specific conductance was 346 µS/cm @ 25 C and the average water color was 30 Pt-Co units.

Aquatic Plants

Conine had a low abundance of aquatic macrophytes with a percent area coverage (PAC) and percent volume infested (PVI) with aquatic macrophytes of < 0.1%, respectively (Table 3). The average above-ground biomass of emergent, floating-leaved and submersed vegetation was 2.7, 0 and 0 kg wet wt/m^2, respectively (Table 3). The average epiphytic algal concentration associated with the aquatic macrophytes was 5.8 mg chlorophyll *a*/cm^2 of host plant and 3.1 mg chlorophyll *a*/kg wet wt of host plant (Table 3). Ten species of aquatic macrophytes were collected in Conine. The most commonly encountered plant species were *Typha* spp., *Colocasia esculenta,* and *Panicum repens* , which occurred in 60%, 40% and 30% of the transects, respectively (Table 154).

The plant community in Lake Conine has been monitored by the Florida Department of

Table 154. Occurrence of plant species in ten evenly-spaced transects around Lake Conine.

Common name	Scientific name	Percent of Transects
spatterdock	*Nuphar luteum*	10
smartweed	*Polygonum hydropiperoides*	30
cat-tail	*Typha* spp.	60
water-pennywort	*Hydrocotyle umbellata*	10
elephant-ear	*Colocasia esculenta*	40
water primrose	*Ludwigia octovalis*	30
willow	*Salix* spp.	30
maidencane	*Panicum hemitomon*	10
para grass	*Brachiaria mutica*	20
torpedograss	*Panicum repens*	30

Natural Resources from 1982 to present. The dominant species for all years was *Typha* spp., which is similar to our findings (Table 154). *Typha* spp., however, never covered over 6% of the lake's surface area. Thus, the fish population in Lake Conine during this study can be considered the product of a hypereutrophic lake with low levels of aquatic vegetation.

Invertebrates

The average number and biomass of epiphytic macroinvertebrates in Conine was 475 individuals/kg wet wt of host plant and 1.61 g wet wt/kg wet wt of host plant (Table 5). Average number and biomass of benthic macroinvertebrates in Conine, as estimated with a ponar dredge, was 2561 individuals/m^2 and 56.31 g wet wt/m^2 (Table 5). The zooplankton population in Lake Conine was dominated by nauplii and rotifers with 217,000 and 134,000 individuals/m^3, respectively (Table 5).

Fish

Twenty species of fish were collected from Conine (Table 155, 156, and 156). The most abundant species collected with rotenone sampling were threadfin shad and bluegill. These species had average standing stocks in littoral blocknets of 6,900 and 1,300 fish/ha, respectively (Table 155). The most abundant **(Text continued on page 349)**

Table 155. Blocknet-rotenone estimates of total and harvestable fish stock (number/hectare) and standing crop (kg/hectare) for Conine. Mean values for littoral and open-water nets are listed by species with the corresponding standard error of the mean.

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Littoral nets (n=3) for total fish				
Gizzard shad	605	186	11.2	2.51
Threadfin shad	6916	5965	15.2	12.90
Golden shiner	25	14	0.0	0.02
Brown bullhead	4	4	0.0	0.00
White catfish	0	0	0.0	0.00
Seminole killifish	49	38	0.4	0.38
Mosquitofish	119	101	0.1	0.04
Tidewater silverside	74	31	0.0	0.02
Warmouth	177	122	2.9	2.51
Bluegill	1256	416	56.5	25.25
Redear sunfish	329	178	23.7	14.61
Spotted sunfish	8	4	0.2	0.17
Largemouth bass	811	178	29.1	15.98
Black crappie	62	62	0.4	0.35
Blue tilapia	700	453	34.4	34.24
Total	11135		174.1	
Littoral nets (n=3) for harvestable fish				
Brown bullhead	0	0.0	0.0	0.00
White catfish	0	0.0	0.0	0.00
Warmouth	12	12.4	1.6	1.61
Bluegill	346	167.7	39.5	19.05
Redear sunfish	140	86.3	19.0	12.38
Spotted sunfish	0	0.0	0.0	0.00
Largemouth bass	45	28.8	19.6	13.96
Black crappie	0	0.0	0.0	0.00
Total	543		79.7	

Table 155. (Concluded)

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Open-water nets (n=3) for total fish				
Gizzard shad	251	95	6.7	2.86
Threadfin shad	30245	23437	72.4	55.25
Golden shiner	0	0	0.0	0.00
Brown bullhead	0	0	0.0	0.00
White catfish	12	12	0.0	0.04
Seminole killifish	0	0	0.0	0.00
Mosquitofish	4	4	0.0	0.00
Tidewater silverside	21	8	0.0	0.00
Warmouth	4	4	0.0	0.00
Bluegill	1437	1314	68.5	67.52
Redear sunfish	156	150	15.5	14.87
Spotted sunfish	0	0	0.0	0.00
Largemouth bass	37	26	3.3	1.65
Black crappie	37	31	0.9	0.48
Blue tilapia	12	12	9.5	9.48
Total	32217		176.8	
Open-water nets (n=3) for harvestable fish				
Brown bullhead	0	0.0	0.0	0.00
White catfish	0	0.0	0.0	0.00
Warmouth	0	0.0	0.0	0.00
Bluegill	358	352.0	28.2	28.12
Redear sunfish	124	117.4	13.5	12.93
Spotted sunfish	0	0.0	0.0	0.00
Largemouth bass	12	7.1	2.9	1.44
Black crappie	4	4.1	0.5	0.54
Total	498		45.1	

Table 156. Experimental gillnet (five 10-meter long sections of 1.9, 2.5, 3.8, 5.1, and 6.4 cm bar mesh, which were 2.4 meter deep) catch per unit effort estimates of total and harvestable fish number (number/net/24 hr) and weight (kg/net/24 hr) for Conine. Mean values for experimental gillnets are listed by species with the corresponding standard error of the mean.

Common Name	Fish number (number/net/24 hr)	Standard Error	Fish weight (kg/net/24 hr)	Standard Error
Gillnets (n=3) for total fish				
Florida gar	6.7	0.67	8.3	0.70
Gizzard shad	21.7	8.19	3.4	0.58
Taillight shiner	0.3	0.33	0.0	0.02
Bluegill	7.7	1.20	0.7	0.09
Redear sunfish	1.0	0.58	0.2	0.09
Largemouth bass	5.0	2.52	1.6	0.78
Sunshine bass	1.3	1.33	1.3	1.27
Black crappie	2.3	0.88	0.4	0.18
Blue tilapia	5.0	1.00	2.8	0.56
Total	51.0		18.7	
Gillnets (n=3) for harvestable fish				
Bluegill	5.7	0.33	0.6	0.02
Redear sunfish	1.0	0.58	0.2	0.09
Largemouth bass	3.7	1.86	1.4	0.72
Sunshine bass	1.3	1.33	1.3	1.27
Black crappie	2.3	0.88	0.4	0.18
Total	14.0		3.9	

Table 157. Electrofishing catch per unit effort estimates of total and harvestable fish number (number/hr) and weight (kg/hr) for Conine. Mean values are listed by species with the corresponding standard error of the mean.

Common Name	Number (number/hr)	Standard Error	Weight (kg/hr)	Standard Error
Electrofishing runs (n=4) for total fish				
Bowfin	1.5	1.50	4.5	4.50
Threadfin shad	291.0	281.00	0.4	0.40
Golden shiner	3.0	3.00	0.0	0.00
Brown bullhead	3.0	1.70	1.9	1.10
Seminole killifish	4.5	2.90	0.1	0.00
Mosquitofish	9.0	3.90	0.0	0.00
Tidewater silverside	6.0	6.00	0.0	0.00
Warmouth	1.5	1.50	0.1	0.10
Bluegill	135.0	34.90	12.3	2.00
Redear sunfish	36.0	15.90	6.7	3.10
Largemouth bass	76.5	23.40	32.7	9.10
Blue tilapia	7.5	2.90	7.0	3.10
Total	574.5		65.6	
Electrofishing runs (n=4) for harvestable fish				
Brown bullhead	3.0	1.73	1.9	1.11
Warmouth	0.0	0.00	0.0	0.00
Bluegill	88.5	12.82	10.6	1.24
Redear sunfish	31.5	15.37	6.4	3.05
Largemouth bass	39.0	12.61	31.5	9.07
Total	162.0		50.5	

open-water species collected in the experimental gillnets were gizzard shad and Florida gar with 22, and 6.7 fish/net/24 hr, respectively (Table 156). The most abundant species collected using electrofishing were threadfin shad and bluegill with catch per unit efforts of 291 and 135 fish per hour, respectively (Table 157). Average first year growth of bluegill, redear sunfish, and largemouth bass was 71, 81, and 171 mm TL, respectively (Table 6). Mark-recapture estimates indicated that there were 469 harvestable bluegill, 39 harvestable redear sunfish, and 40 harvestable largemouth bass per hectare in Lake Conine (Table 7).

The fish population in Lake Conine was sampled with rotenone and two blocknets in 1969 by the Florida Game and Freshwater Fish Commission (Buntz and Manooch 1970). The total fish biomass averaged 236 kg/ha, which is similar to the littoral value reported for this study (174 kg/ha; Table 155). Both sampling periods collected 15 species of fish in relatively the same ratios. Thus, it seems the fish population in Lake Conine has remained stable over the last 20 years.

Tomohawk

Location and Morphology

Tomohawk is located in Marion County, Florida (Latitude 29.08 N; Longitude 81.54 W). The lake lies in the Oklawaha Valley division of the Ocala Uplift District (Brooks 1981). The geology is dominated by deeply weathered clayey sand and granular sands of the Hawthorne Formation. Tomohawk was sampled from 1988 to 1989 and had a surface area, shoreline length, and mean depth of 15 ha, 4.01 km, and 4.4 m, respectively (Table 1).

Trophic Status and Water Chemistry

Tomohawk had an average total phosphorus concentration of 6 µg/L and an average total nitrogen concentration of 192 µg/L. Total chlorophyll *a* concentrations averaged 1 µg/L and the water clarity as measured by use of a Secchi disc averaged 4.2 m (Table 2). The lake had an average pH of 4.9 and an average total alkalinity of 1.0 mg/L as $CaCO_3$. The average specific conductance was 35 µS/cm @ 25 C and the average water color was 0 Pt-Co units. The adjusted chlorophyll *a* value for Tomohawk was 2.6 µg/L. Using this value and the classification system of Forsberg and Ryding (1980), Tomohawk was classified as an oligotrophic lake during this study.

Aquatic Plants

Tomohawk had a moderate abundance of aquatic macrophytes with a percent area coverage (PAC) and percent volume infested (PVI) with aquatic macrophytes of 43% and 12%, respectively (Table 3). The average above-ground biomass of emergent, floating-leaved and submersed vegetation was 1.4, 0.5 and 0.9 kg wet wt/m^2, respectively (Table 3). The average epiphytic algal concentration associated with the aquatic macrophytes was 14.7 mg chlorophyll *a*/cm^2 of host plant and 40.8 mg chlorophyll *a*/kg wet wt of host plant (Table 3). Seventeen species of aquatic macrophytes were collected from Tomohawk (Table 158). The most commonly encountered plant species were *Nymphoides aquatica, Myriophyllum heterophyllum,* and *Utricularia purpurea,* which occurred in 100%, 100%, and 100% of the transects, respectively.

Table 158. Occurrence of plant species in ten evenly-spaced transects around Lake Tomohawk.

Common name	Scientific name	Percent of Transects
alligator-weed	*Alternanthera philoxeroides*	10
banana-lily	*Nymphoides aquatica*	100
water-shield	*Brasenia schreberi*	50
spatterdock	*Nuphar luteum*	30
fragrant water-lily	*Nymphaea odorata*	60
red ludwigia	*Ludwigia repens*	90
lemon bacopa	*Bacopa caroliniana*	50
water-pennywort	*Hydrocotyle umbellata*	20
variable-leaf milfoil	*Myriophyllum heterophyllum*	100
purple bladderwort	*Utricularia purpurea*	100
maidencane	*Panicum hemitomon*	40
	Fuirena sciropoidea	70
	Leersia hexandra	60
	Utricularia floridana	30
pipewort	*Eriocaulon* spp.	20
St. John's wort	*Hypericum* spp.	40
yellow-eyed grass	*Xyris* spp.	50

The plant community of Tomohawk was sampled in 1985 by Canfield and Joyce (1985). The percent of the lake covered with vegetation was large (95%) and the dominant species of plants collected were *Myriophyllum heterophyllum* and *Utricularia purpurea.*

Plant coverage was a greater during Canfield and Joyce's study than ours (Table 3 and 158). It, therefore, seems that the percent area covered with vegetation in Tomohawk has decreased slightly in three years. The fish population of Tomohawk, however, can be considered the product of an oligotrophic lake with moderate levels of aquatic vegetation.

Invertebrates

The average number and biomass of epiphytic macroinvertebrates in Tomohawk was 107 individuals/kg wet wt of host plant and 0.06 g wet wt/kg wet wt of host plant (Table 5). Average number and biomass of benthic macroinvertebrates in Tomohawk, as estimated with a ponar dredge, was 227 individuals/m^2 and 0.16 g wet wt/m^2 (Table 5). The zooplankton population in Tomohawk was dominated by copepods and nauplii with 36,300 and 25,500 individuals/m^3, respectively (Table 5).

Fish

Thirteen species of fish were collected from Tomohawk (Table 159, 160, and 161). The most abundant species collected with rotenone sampling were bluegill and warmouth. These species had average standing stocks in littoral blocknets of 5,300 and 3,180 fish/ha, respectively (Table 159). The most abundant open-water species collected in the experimental gillnets were lake chubsucker and largemouth bass with 2.5 and 1 fish/net/24 hr, respectively (Table 160). The most abundant species collected using electrofishing were lake chubsucker and bluegill with catch per unit efforts of 18 and 16.5 fish per hour, respectively (Table 161). Average first year growth of bluegill and largemouth bass was 38 and 141 mm TL, respectively (Table 6). Mark-recapture estimates indicated that there were 40 harvestable largemouth bass per hectare in Lake Tomohawk (Table 7).

The fish population in Tomohawk was monitored with electrofishing in 1985 by the US Forest Service. The average total fish catch per unit effort averaged 20 kg/hour, which is higher then the 7.2 kg/hour reported for this study (Table 161). A mark-recapture estimate for harvestable largemouth bass was also conducted by the US Forest Service and they estimated that there were 32 largemouth bass/ha, which is similar to our mark-recapture estimate of 40 largemouth bass/ha. These data suggest that the fish population in Tomohawk has remained relatively stable for the last several years. **(Text continued on page 355)**

Table 159. Blocknet-rotenone estimates of total and harvestable fish stock (number/hectare) and standing crop (kg/hectare) for Tomohawk. Mean values for littoral and open-water nets are listed by species with the corresponding standard error of the mean.

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Littoral nets (n=2) for total fish				
Lake chubsucker	883	315	23.2	2.97
Yellow bullhead	37	37	6.1	6.13
Golden topminnow	482	296	0.6	0.39
Lined topminnow	229	228	0.3	0.29
Mosquitofish	25	25	0.0	0.00
Least killifish	37	12	0.0	0.00
Pygmy killifish	0	0	0.0	0.00
Warmouth	3180	389	25.0	3.67
Bluegill	5298	1396	27.7	9.79
Dollar sunfish	679	395	1.6	0.80
Largemouth bass	290	68	14.8	6.87
Swamp darter	62	49	0.1	0.06
Total	11201		99.3	
Open-water nets (n=2) for total fish				
Lake chubsucker	19	19	1.7	1.73
Yellow bullhead	0	0	0.0	0.00
Golden topminnow	31	19	0.0	0.03
Lined topminnow	0	0	0.0	0.00
Mosquitofish	0	0	0.0	0.00
Least killifish	25	25	0.0	0.00
Pygmy killifish	12	12	0.0	0.00
Warmouth	154	117	1.5	1.41
Bluegill	14196	7330	13.5	3.68
Dollar sunfish	0	0	0.0	0.00
Largemouth bass	142	56	17.2	8.35
Swamp darter	0	0	0.0	0.00
Total	14579		34.0	

Table 159. (Concluded)

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Littoral nets (n=2) for harvestable fish				
Yellow bullhead	19	18.5	5.3	5.25
Warmouth	25	12.3	2.5	1.26
Bluegill	49	24.7	3.7	1.75
Dollar sunfish	0	0.0	0.0	0.00
Largemouth bass	31	18.5	7.8	5.33
Total	124		19.3	
Open-water nets (n=2) for harvestable fish				
Yellow bullhead	0	0.0	0.0	0.00
Warmouth	0	0.0	0.0	0.00
Bluegill	12	12.3	1.0	0.99
Dollar sunfish	0	0.0	0.0	0.00
Largemouth bass	49	24.7	14.0	6.68
Total	62		15.0	

Table 160. Experimental gillnet (five 10-meter long sections of 1.9, 2.5, 3.8, 5.1, and 6.4 cm bar mesh, which were 2.4 meter deep) catch per unit effort estimates of total and harvestable fish number (number/net/24 hr) and weight (kg/net/24 hr) for Tomohawk. Mean values for experimental gillnets are listed by species with the corresponding standard error of the mean.

Common Name	Fish number (number/net/24 hr)	Standard Error	Fish weight (kg/net/24 hr)	Standard Error
Gillnets (n=2) for total fish				
Lake chubsucker	2.5	1.50	0.5	0.39
Yellow bullhead	1.0	0.00	0.3	0.03
Bluegill	1.0	1.00	0.0	0.03
Largemouth bass	1.0	1.00	0.1	0.13
Total	5.5		0.9	
Gillnets (n=2) for harvestable fish				
Yellow bullhead	1.0	0.00	0.3	0.03
Bluegill	0.0	0.00	0.0	0.00
Largemouth bass	0.5	0.50	0.1	0.07
Total	1.5		0.4	

Table 161. Electrofishing catch per unit effort estimates of total and harvestable fish number (number/hr) and weight (kg/hr) for Tomohawk. Mean values are listed by species with the corresponding standard error of the mean.

Common Name	Number (number/hr)	Standard Error	Weight (kg/hr)	Standard Error
Electrofishing runs (n=4) for total fish				
Lake chubsucker	18.0	6.50	2.5	1.10
Golden topminnow	1.5	1.50	0.0	0.00
Lined topminnow	3.0	1.70	0.0	0.00
Brook silverside	1.5	1.50	0.0	0.00
Warmouth	3.0	3.00	0.0	0.00
Bluegill	16.5	6.20	0.3	0.20
Largemouth bass	10.5	5.10	4.4	2.10
Total	54.0		7.3	
Electrofishing runs (n=4) for harvestable fish				
Warmouth	0.0	0.00	0.0	0.00
Bluegill	1.5	1.50	0.2	0.24
Largemouth bass	4.5	1.50	3.9	1.84
Total	6.0		4.1	

Lake Barco

Location and Morphology

Lake Barco is located in Putnam County, Florida (Latitude 29.40 N; Longitude 82.00 W). The lake lies in the Interlachen Sand Hills division of the Central Lakes District (Brooks 1981). The geology is dominated quartz sand and quartzite gravel with basal kaolinitic sandy clay beds of the Hawthorne Formation. Barco was sampled from 1988 to 1989 and had a surface area, shoreline length, and mean depth of 13 ha, 1.29 km and 4.4 m, respectively (Table 1).

Trophic Status and Water Chemistry

Lake Barco is an oligotrophic lake. Lake Barco had an average total phosphorus concentration of 2 µg/L and an average total nitrogen concentration of 82 µg/L during this study. Total chlorophyll *a* concentrations averaged 1.0 µg/L and the water clarity as measured by use of a Secchi disc averaged 5.4 m (Table 2). The lake had an average pH of 4.5 and an average total alkalinity of 0.1 mg/L as $CaCO_3$. The average specific conductance was 43 µS/cm @ 25 C and the average water color was 1.7 Pt-Co units.

Aquatic Plants

Lake Barco had a low abundance of aquatic macrophytes with a percent area coverage (PAC) and percent volume infested (PVI) with aquatic macrophytes of 37% and 1.3%, respectively (Table 3). The average above-ground biomass of emergent, floating-leaved and submersed vegetation was 1.6, 0 and 0.7 kg wet wt/m^2, respectively (Table 3). The average epiphytic algal concentration associated with the aquatic macrophytes was 22.8 mg chlorophyll *a*/cm^2 of host plant and 44.2 mg chlorophyll *a*/kg wet wt of host plant (Table 3). Nine species of aquatic macrophytes were collected in Barco. The most commonly encountered plant species were *Leersia hexandra, Hypericum* spp., and *Utricularia resupinata, which occurred in* 100%, 100%, and 100% of the transects, respectively (Table 162).

No previous vegetation studies have been conducted on Lake Barco, but the lake is undeveloped and located on the Katherine Ordway Preserve. Thus, the vegetation has probably remained stable for the last several years and the fish population in Barco can be considered the product of an oligotrophic lake with moderate to low levels of aquatic vegetation.

Invertebrates

The average number and biomass of epiphytic macroinvertebrates in Barco was 104 individuals/kg wet wt of host plant and 0.19 g wet wt/kg wet wt of host plant (Table 5). Average number and biomass of benthic macroinvertebrates in Barco, as estimated with a ponar dredge, was 747 individuals/m^2 and 2.37 g wet wt/m^2 (Table 5). The zooplankton population in Barco was dominated by copepods and nauplii with 36,300 and 3,300

Table 162. Occurrence of plant species in ten evenly-spaced transects around Lake Barco.

Common name	Scientific name	Percent of Transects
slender spikerush	*Eleocharis baldwinii*	90
red ludwigia	*Ludwigia repens*	80
maidencane	*Panicum hemitomon*	40
	Fuirena sciropoidea	70
	Leersia hexandra	100
pipewort	*Eriocaulon* spp.	10
St. John's wort	*Hypericum* spp.	100
yellow-eyed grass	*Xyris* spp.	10
	Utricularia resupinata	100

individuals/m^3, respectively (Table 5).

Fish

Nine species of fish were collected from Barco (Table 163, 164 and 165). The most abundant species collected with rotenone sampling were warmouth and mosquitofish. These species had average standing stocks in littoral blocknets of 333 and 74 fish/ha, respectively (Table 163). The most abundant open-water species collected in the experimental gillnets was bluegill with 1 fish/net/24 hr, respectively (Table 164). The most abundant species collected using electrofishing were bluegill and golden shiner with catch per unit efforts of 60, and 51 fish per hour, respectively (Table 165). Average first year growth of bluegill and largemouth bass was 58 and 175 mm TL, respectively (Table 6). Mark-recapture estimates indicated that there were 154 harvestable bluegill and 1 harvestable largemouth bass per hectare in Lake Barco (Table 7).

No previous fisheries studies have been done on Barco. Barco, however, is on undeveloped land in the Katherine Ordway Preserve and no major change in the fish population would be expected over the last several years. **(Text continued on page 361)**

Table 163. Blocknet-rotenone estimates of total and harvestable fish stock (number/hectare) and standing crop (kg/hectare) for Lake Barco. Mean values for littoral and open-water nets are listed by species with the corresponding standard error of the mean.

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Littoral nets (n=2) for total fish				
Mosquitofish	74	74	0.0	0.03
Warmouth	333	296	5.8	5.21
Bluegill	68	68	4.8	4.76
Largemouth bass	12	0	0.8	0.02
Swamp darter	93	43	0.0	0.03
Total	580		11.4	
Littoral nets (n=2) for harvestable fish				
Warmouth	0	0.0	0.0	0.00
Bluegill	56	55.6	4.2	4.19
Total	56		4.2	
Open-water nets (n=2) for total fish				
Mosquitofish	0	0	0.0	0.00
Warmouth	0	0	0.0	0.00
Bluegill	19	6	2.9	0.62
Largemouth bass	12	0	1.1	0.36
Swamp darter	0	0	0.0	0.00
Total	31		4.0	
Open-water nets (n=2) for harvestable fish				
Warmouth	0	0.0	0.0	0.00
Bluegill	19	6.2	2.9	0.62
Total	19		2.9	

Table 164. Experimental gillnet (five 10-meter long sections of 1.9, 2.5, 3.8, 5.1, and 6.4 cm bar mesh, which were 2.4 meter deep) catch per unit effort estimates of total and harvestable fish number (number/net/24 hr) and weight (kg/net/24 hr) for Lake Barco. Mean values for experimental gillnets are listed by species with the corresponding standard error of the mean.

Common Name	Fish number (number/net/24 hr)	Standard Error	Fish weight (kg/net/24 hr)	Standard Error
Gillnets (n=2) for total fish				
Bluegill	1.0	0.00	0.1	0.03
Total	1.0		0.1	
Gillnets (n=2) for harvestable fish				
Bluegill	0.5	0.50	0.1	0.05
Total	0.5		0.1	

Table 165. Electrofishing catch per unit effort estimates of total and harvestable fish number (number/hr) and weight (kg/hr) for Lake Barco. Mean values are listed by species with the corresponding standard error of the mean.

Common Name	Number (number/hr)	Standard Error	Weight (kg/hr)	Standard Error
Electrofishing runs (n=4) for total fish				
Chain pickerel	1.5	1.5	0.0	0.0
Golden shiner	51.0	51.0	0.2	0.2
Lake chubsucker	10.5	10.5	0.1	0.1
Mosquitofish	1.5	1.5	0.0	0.0
Brook silverside	7.5	7.5	0.0	0.0
Warmouth	6.0	6.0	0.1	0.1
Bluegill	60.0	44.2	1.3	0.4
Largemouth bass	16.5	12.6	2.8	2.2
Total	154.5		4.6	
Electrofishing runs (n=4) for harvestable fish				
Chain pickerel	0.0	0.00	0.0	0.00
Warmouth	0.0	0.00	0.0	0.00
Bluegill	13.5	5.12	1.0	0.43
Largemouth bass	1.5	1.50	2.3	2.29
Total	15.0		3.3	

Suggs

Location and Morphology

Suggs is located in Putnam County, Florida (Latitude 29.41 N; Longitude 82.01 N). The lake lies in the Interlachen Sand Hills division of the Central Lakes District (Brooks 1981). The geology is dominated quartz sand and quartzite gravel with basal kaolinitic sandy clay beds of the Hawthorne Formation. Suggs was sampled from 1988 to 1989 and had a surface area, shoreline length, and mean depth of 73 ha, 2.30 km and 2 m, respectively (Table 1).

Trophic Status and Water Chemistry

Suggs is a mesotrophic lake. Suggs had an average total phosphorus concentration of 66 μg/L and an average total nitrogen concentration of 1249 μg/L during this study. Total chlorophyll *a* concentrations, however, averaged 4 μg/L and the water clarity as measured by use of a Secchi disc averaged 0.5 meters (Table 2). The lake had an average pH of 5.0 and an average total alkalinity of 2 mg/L as $CaCO_3$. The average specific conductance was 60 μS/cm @ 25 C and the average water color was 400 Pt-Co units.

Aquatic Plants

Suggs had a low abundance of aquatic macrophytes with a percent area coverage (PAC) and percent volume infested (PVI) with aquatic macrophytes of < 0.1%, respectively (Table 3). The average above-ground biomass of emergent, floating-leaved and submersed vegetation was 0.9, 0.4, and 0 kg wet wt/m^2, respectively (Table 3). The average epiphytic algal concentration associated with the aquatic macrophytes was 15.4 mg chlorophyll *a*/cm^2 of host plant and 14.5 mg chlorophyll *a*/kg wet wt of host plant (Table 3). Nine species of aquatic macrophytes were collected from Suggs (Table 166). The most commonly encountered plant species were *Brachiaria mutica, Nuphar luteum,* and *Panicum hemitomon,* which occurred in 100%, 90%, and 80% of the transects, respectively.

No previous vegetation studies have been conducted on Suggs, but Suggs is an undeveloped lake in the Katherine Ordway Preserve and the vegetation has probably remained stable for the last several years. Thus, the fish population in Suggs can be

Table 166. Occurrence of plant species in ten evenly-spaced transects around Lake Suggs.

Common name	Scientific name	Percent of Transects
common duckweed	*Lemna minor*	10
slender spikerush	*Eleocharis baldwinii*	10
frog's-bit	*Limnobium spongia*	10
spatterdock	*Nuphar luteum*	90
pickerelweed	*Pontederia cordata*	40
water-pennywort	*Hydrocotyle umbellata*	80
sawgrass	*Cladium jamaicense*	20
maidencane	*Panicum hemitomon*	80
para grass	*Brachiaria mutica*	100

considered the product of a mesotrophic lake with low levels of aquatic vegetation.

Invertebrates

The average number and biomass of epiphytic macroinvertebrates in Suggs was 167 individuals/kg wet wt of host plant and 0.53 g wet wt/kg wet wt of host plant (Table 5). Average number and biomass of benthic macroinvertebrates in Suggs, as estimated with a ponar dredge, was 713 individuals/m^2, and 1.47 g wet wt/m^2 (Table 5). The zooplankton population in Suggs was dominated by rotifers and copepods with 153,600 and 65,500 individuals/m^3, respectively (Table 5).

Fish

Twenty species of fish were collected from Suggs (Table 167, 168 and 169). The most abundant species collected with rotenone sampling were warmouth and bluespotted sunfish. These species had average standing stocks in littoral blocknets of 1,600 and 140 fish/ha, respectively (Table 167). The most abundant open-water species collected in the experimental gillnets were bowfin and Florida gar with 34 and 9.3 fish/net/24 hr, respectively (Table 168). The most abundant species collected using electrofishing were bluegill and largemouth bass with catch per unit efforts of 28 and 18 fish per hour, respectively (Table 169). Average first year **(Text continued on page 366)**

Table 167. Blocknet-rotenone estimates of total and harvestable fish stock (number/hectare) and standing crop (kg/hectare) for Suggs. Mean values for littoral and open-water nets are listed by species with the corresponding standard error of the mean.

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Littoral nets (n=3) for total fish				
Redfin pickerel	29	11	0.1	0.08
Golden shiner	0	0	0.0	0.00
Lake chubsucker	25	19	0.1	0.04
Yellow bullhead	111	19	1.6	0.95
Tadpole madtom	21	11	0.1	0.03
Golden topminnow	25	19	0.1	0.03
Mosquitofish	8	4	0.0	0.00
Least killifish	8	8	0.0	0.00
Brook silverside	91	54	0.1	0.06
Pirate perch	41	23	0.2	0.10
Bluespotted sunfish	144	39	0.2	0.05
Warmouth	1610	165	4.8	1.18
Bluegill	284	70	2.4	1.49
Redear sunfish	4	4	1.4	1.39
Largemouth bass	99	40	0.8	0.36
Black crappie	4	4	0.0	0.01
Swamp darter	29	4	0.0	0.00
Total	2532		11.8	
Littoral nets (n=3) for harvestable fish				
Yellow bullhead	4	4.1	0.6	0.59
Warmouth	8	4.1	1.2	0.61
Bluegill	12	7.1	1.8	1.32
Redear sunfish	4	4.1	1.4	1.39
Largemouth bass	0	0.0	0.0	0.00
Black crappie	0	0.0	0.0	0.00
Total	29		4.9	

Table 167. (Concluded)

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Open-water nets (n=3) for total fish				
Redfin pickerel	0	0	0.0	0.00
Golden shiner	4	4	0.6	0.56
Lake chubsucker	0	0	0.0	0.00
Yellow bullhead	4	4	0.0	0.01
Tadpole madtom	0	0	0.0	0.00
Golden topminnow	0	0	0.0	0.00
Mosquitofish	0	0	0.0	0.00
Least killifish	4	4	0.0	0.00
Brook silverside	21	21	0.0	0.03
Pirate perch	0	0	0.0	0.00
Bluespotted sunfish	0	0	0.0	0.00
Warmouth	235	222	0.7	0.71
Bluegill	309	155	13.4	4.15
Redear sunfish	0	0	0.0	0.00
Largemouth bass	0	0	0.0	0.00
Black crappie	967	531	5.2	1.36
Swamp darter	0	0	0.0	0.00
Total	1544		19.9	
Open-water nets (n=3) for harvestable fish				
Yellow bullhead	0	0.0	0.0	0.00
Warmouth	0	0.0	0.0	0.00
Bluegill	78	29.7	12.4	4.60
Redear sunfish	0	0.0	0.0	0.00
Largemouth bass	0	0.0	0.0	0.00
Black crappie	8	8.2	1.5	1.48
Total	86		13.9	

Table 168. Experimental gillnet (five 10-meter long sections of 1.9, 2.5, 3.8, 5.1, and 6.4 cm bar mesh, which were 2.4 meter deep) catch per unit effort estimates of total and harvestable fish number (number/net/24 hr) and weight (kg/net/24 hr) for Suggs. Mean values for experimental gillnets are listed by species with the corresponding standard error of the mean.

Common Name	Fish number (number/net/24 hr)	Standard Error	Fish weight (kg/net/24 hr)	Standard Error
Gillnets (n=3) for total fish				
Florida gar	9.3	2.18	2.1	0.55
Bowfin	34.0	6.24	7.6	1.48
Redfin pickerel	0.3	0.32	0.2	0.24
Chain pickerel	1.0	0.00	0.6	0.24
Golden shiner	3.7	1.76	1.7	0.84
Lake chubsucker	0.3	0.32	0.2	0.15
Yellow bullhead	0.3	0.32	0.1	0.06
Warmouth	5.8	1.30	0.2	0.06
Bluegill	0.2	0.18	0.0	0.01
Largemouth bass	9.0	1.00	0.8	0.08
Total	64.0		13.5	
Gillnets (n=3) for harvestable fish				
Chain pickerel	0.3	0.33	0.2	0.21
Yellow bullhead	1.3	0.88	0.4	0.18
Warmouth	0.3	0.33	0.0	0.05
Bluegill	0.3	0.33	0.1	0.05
Largemouth bass	0.0	0.00	0.0	0.00
Total	2.3		0.7	

Table 169. Electrofishing catch per unit effort estimates of total and harvestable fish number (number/hr) and weight (kg/hr) for Suggs. Mean values are listed by species with the corresponding standard error of the mean.

Common Name	Number (number/hr)	Standard Error	Weight (kg/hr)	Standard Error
Electrofishing runs (n=3) for total fish				
Bluegill	28.0	14.00	7.3	0.32
Largemouth bass	18.0	18.00	1.1	0.11
Total	46.0		8.4	
Electrofishing runs (n=3) for harvestable fish				
Bluegill	2.0	2.00	0.5	0.45
Largemouth bass	0.0	0.00	0.0	0.00
Total	2.0		0.5	

growth of bluegill, redear sunfish and largemouth bass was 46, 64 and 142 mm TL, respectively (Table 6). Mark-recapture estimates indicated that there were 22 harvestable bluegill, 1 harvestable redear sunfish, and 1 harvestable largemouth bass per hectare in Lake Suggs (Table 7).

No previous fisheries studies have been done on Suggs, but Suggs is on undeveloped land in the Katherine Ordway Preserve and no major change in the fish population would be expected over the last several years.

Lake Carlton

Location and Morphology

Lake Carlton is located in Orange County, Florida (Latitude 28.45 N; Longitude 81.39 W). The lake lies in the Central Lakes division of the Central Lake District (Brooks 1981). The geology is dominated by deeply weathered clayey sand, and granular sand of the phosphatic Hawthorne Formation. Carlton was sampled from 1988 to 1989 and had a surface area, shoreline length, and mean depth of 155 ha, 4.51 km and 3.6 m, respectively (Table 1).

Trophic Status and Water Chemistry

Carlton had an average total phosphorus concentration of 92 µg/L and an average total nitrogen concentration of 3228 µg/L. Total chlorophyll *a* concentrations averaged 173 µg/L and the water clarity as measured by use of a Secchi disc averaged 0.4 m (Table 2). The lake had an average pH of 8.9 and an average total alkalinity of 105 mg/L as $CaCO_3$. The average specific conductance was 384 µS/cm @ 25 C and the average water color was 37 Pt-Co units. Using the classification system of Forsberg and Ryding (1980), Carlton was classified as a hypereutrophic lake during this study.

Aquatic Plants

Lake Carlton had a low abundance of aquatic macrophytes with a percent area coverage (PAC) and percent volume infested (PVI) with aquatic macrophytes of < 0.1%, respectively (Table 3). The average above-ground biomass of emergent, floating-leaved and submersed vegetation was 2.4, 0.2, and 0.4 kg wet wt/m^2, respectively (Table 3). The average epiphytic algal concentration associated with the aquatic macrophytes was 14.3 mg chlorophyll *a*/cm^2 of host plant and 5.5 mg chlorophyll *a*/kg wet wt of host plant (Table 3). Ten species of aquatic macrophytes were collected from Lake Carlton. The most commonly encountered plant species were *Typha* spp., *Paspalum distichum,* and *Nuphar luteum* , which occurred in 80%, 30% and 20% of the transects, respectively (Table 170).

The plant community of Carlton has been monitored by the Florida Department of Natural Resources from 1982 to present. The major aquatic plants in the lake were *Typha* spp. and *Paspalum distichum*, which is similar to our findings. These plants, however,

Table 170. Occurrence of plant species in ten evenly-spaced transects around Lake Carlton.

Common name	Scientific name	Percent of Transects
spatterdock	*Nuphar luteum*	20
pickerelweed	*Pontederia cordata*	10
cat-tail	*Typha* spp.	80
tapegrass	*Vallisneria americana*	20
elephant-ear	*Colocasia esculenta*	20
buttonbush	*Cephalanthus occidentalis*	10
soft rush	*Juncus effusus*	10
knot grass	*Paspalum distichum*	30
bald cypress	*Taxodium distichum*	10
blue maidencane	*Amphicarpum muhlenbergianum*	20

never covered more than 5% of Carlton's surface area. Thus, the fish in Carlton can be considered the product of a hypereutrophic lake with low levels of aquatic vegetation.

Invertebrates

The average number and biomass of epiphytic macroinvertebrates in Carlton was 406 individuals/kg wet wt of host plant and 0.99 g wet wt/kg wet wt of host plant (Table 5). Average number and biomass of benthic macroinvertebrates in Carlton, as estimated with a ponar dredge, was 2733 individuals/m^2 and 6.02 g wet wt/m^2 (Table 5). The zooplankton population in Carlton was dominated by rotifers and nauplii with 878,000 and 178,000 individuals/m^3, respectively (Table 5).

Fish

Twenty-five species of fish were collected from Lake Carlton (Table 171, 172 and 173). The most abundant species collected with rotenone sampling were bluegill and redear sunfish. These species had average standing stocks in littoral blocknets of 6,500 and 2,100 fish/ha, respectively (Table 171). The most abundant open-water species collected in the experimental gillnets were gizzard shad and longnose gar with 19 and 4.3 fish/net/24 hr, respectively (Table 172). The most abundant **(Text continued on page 374)**

Table 171. Blocknet-rotenone estimates of total and harvestable fish stock (number/hectare) and standing crop (kg/hectare) for Carlton. Mean values for littoral and open-water nets are listed by species with the corresponding standard error of the mean.

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Littoral nets (n=3) for total fish				
Longnose gar	4	4	0.1	0.15
Gizzard shad	1939	1434	34.2	17.58
Threadfin shad	1173	1008	2.3	2.00
Golden shiner	1009	646	2.2	1.17
Taillight shiner	284	284	0.2	0.15
Yellow bullhead	12	12	0.5	0.47
Brown bullhead	8	4	0.0	0.01
Seminole killifish	37	25	0.3	0.17
Mosquitofish	449	424	0.1	0.13
Sailfin molly	148	148	0.2	0.21
Tidewater silverside	4	4	0.0	0.00
Bluespotted sunfish	21	21	0.0	0.03
Redbreast sunfish	66	66	0.5	0.51
Warmouth	720	641	3.4	2.57
Bluegill	6467	419	395.0	95.44
Redear sunfish	2083	114	170.5	82.81
Spotted sunfish	119	119	0.5	0.49
Largemouth bass	408	180	51.3	9.55
Sunshine bass	4	4	0.0	0.05
Black crappie	782	181	7.5	2.92
Blue tilapia	469	352	80.3	41.65
Atlantic needlefish	0	0	0.0	0.00
Total	16207		749.2	

Table 171. (Continued)

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Open-water nets (n=3) for total fish				
Longnose gar	0	0	0.0	0.00
Gizzard shad	2795	2270	193.6	122.53
Threadfin shad	6056	3214	11.8	6.34
Golden shiner	0	0	0.0	0.00
Taillight shiner	0	0	0.0	0.00
Yellow bullhead	0	0	0.0	0.00
Brown bullhead	0	0	0.0	0.00
Seminole killifish	0	0	0.0	0.00
Mosquitofish	0	0	0.0	0.00
Sailfin molly	0	0	0.0	0.00
Tidewater silverside	4	4	0.0	0.00
Bluespotted sunfish	0	0	0.0	0.00
Redbreast sunfish	0	0	0.0	0.00
Warmouth	25	25	0.0	0.01
Bluegill	1684	1671	17.9	17.85
Redear sunfish	395	389	37.8	37.78
Spotted sunfish	0	0	0.0	0.00
Largemouth bass	0	0	0.0	0.00
Sunshine bass	0	0	0.0	0.00
Black crappie	436	216	3.7	1.90
Blue tilapia	0	0	0.0	0.00
Atlantic needlefish	4	4	0.0	0.02
Total	11399		264.7	

Table 171. (Concluded)

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Littoral nets (n=3) for harvestable fish				
Yellow bullhead	4	4.1	0.5	0.45
Brown bullhead	0	0.0	0.0	0.00
Redbreast sunfish	0	0.0	0.0	0.00
Warmouth	8	4.1	0.8	0.42
Bluegill	2515	640.4	370.2	95.33
Redear sunfish	947	435.3	166.9	83.84
Spotted sunfish	0	0.0	0.0	0.00
Largemouth bass	74	7.1	48.2	8.32
Sunshine bass	0	0.0	0.0	0.00
Black crappie	4	4.1	0.5	0.49
Total	3553		587.1	
Open-water nets (n=3) for harvestable fish				
Yellow bullhead	0	0.0	0.0	0.00
Brown bullhead	0	0.0	0.0	0.00
Redbreast sunfish	0	0.0	0.0	0.00
Warmouth	0	0.0	0.0	0.00
Bluegill	99	98.8	9.4	9.41
Redear sunfish	247	247.0	37.2	37.20
Spotted sunfish	0	0.0	0.0	0.00
Largemouth bass	0	0.0	0.0	0.00
Sunshine bass	0	0.0	0.0	0.00
Black crappie	8	4.1	1.0	0.50
Total	354		47.6	

Table 172. Experimental gillnet (five 10-meter long sections of 1.9, 2.5, 3.8, 5.1, and 6.4 cm bar mesh, which were 2.4 meter deep) catch per unit effort estimates of total and harvestable fish number (number/net/24 hr) and weight (kg/net/24 hr) for Lake Carlton. Mean values for experimental gillnets are listed by species with the corresponding standard error of the mean.

Common Name	Fish number (number/net/24 hr)	Standard Error	Fish weight (kg/net/24 hr)	Standard Error
Gillnets (n=3) for total fish				
Florida gar	0.7	0.33	1.3	0.63
Longnose gar	4.3	2.40	9.5	4.48
Gizzard shad	19.0	8.54	5.7	1.94
Golden shiner	0.3	0.33	0.0	0.00
Black crappie	1.7	0.88	0.3	0.18
Total	26.0		16.8	
Gillnets (n=3) for harvestable fish				
Black crappie	1.0	0.58	0.3	0.17
Total	1.0		0.3	

Table 173. Electrofishing catch per unit effort estimates of total and harvestable fish number (number/hr) and weight (kg/hr) for Lake Carlton. Mean values are listed by species with the corresponding standard error of the mean.

Common Name	Number (number/hr)	Standard Error	Weight (kg/hr)	Standard Error
Electrofishing runs (n=3) for total fish				
Florida gar	36.0	24.98	328.6	19.27
Bowfin	6.0	3.46	106.2	5.98
Gizzard shad	4.0	4.00	11.0	1.10
Threadfin shad	2.0	2.00	0.0	0.00
Golden shiner	30.0	6.93	0.8	0.04
White catfish	2.0	2.00	8.7	0.87
Warmouth	2.0	2.00	0.0	0.00
Bluegill	182.0	30.27	281.2	0.85
Redear sunfish	82.0	17.09	183.1	7.02
Largemouth bass	28.0	5.29	237.9	11.64
Total	374.0		1157.6	
Electrofishing runs (n=3) for harvestable fish				
White catfish	2.0	2.00	0.9	0.87
Warmouth	0.0	0.00	0.0	0.00
Bluegill	154.0	13.11	26.7	0.73
Redear sunfish	78.0	15.87	18.2	6.90
Largemouth bass	20.0	8.00	23.5	11.85
Total	254.0		69.2	

species collected using electrofishing were bluegill and redear sunfish with catch per unit efforts of 182 and 82 fish per hour, respectively (Table 173). Average first year growth of bluegill, and largemouth bass was 69 and 166 mm TL, respectively (Table 6). Mark-recapture estimates indicated that there were 210 harvestable bluegill, 135 harvestable redear sunfish and 8 harvestable largemouth bass per hectare (Table 7) in Lake Carlton.

A complete drawdown of Lake Carlton was conducted in 1977 to consolidate the sediments and increase potential fish habitat (Johnson et al. 1978). A year after Carlton refilled two littoral blocknets captured an average of 770 kg/ha (Johnson et al.1978), which was almost identical to the 750 kg/ha reported for this study (Table 171). Thus, it seems the total fish standing crop in Carlton has remained stable for the last several years after the drawdown.

Lake Rowell

Location and Morphology

Lake Rowell is located in Bradford County, Florida (Latitude 29.55 N; Longitude 82.09 W). The lake lies in the Perched Lakes and Prairies division of the Central Lake District (Brooks 1981). The geology is dominated by deeply weathered clayey sand and granular sand of the Hawthorne Formation. Rowell was sampled from 1988 to 1989 and had a surface area, shoreline length, and mean depth of 147 ha, 5.18 km and 1.3 m, respectively (Table 1).

Trophic Status and Water Chemistry

Lake Rowell had an average total phosphorus concentration of 66 µg/L and an average total nitrogen concentration of 910 µg/L. Total chlorophyll *a* concentrations averaged 47 µg/L and the water clarity as measured by use of a Secchi disc averaged 0.8 m (Table 2). The lake had an average pH of 7.9 and an average total alkalinity of 22.3 mg/L as $CaCO_3$. The average specific conductance was 286 µS/cm @ 25 C and the average water color was 87 Pt-Co units. Using the classification system of Forsberg and Ryding (1980), Lake Rowell was classified as a hypereutrophic lake during this study.

Aquatic Plants

Lake Rowell had a moderate abundance of aquatic macrophytes with a percent area coverage (PAC) and percent volume infested (PVI) with aquatic macrophytes of 43%, and 10%, respectively (Table 3). The average above-ground biomass of emergent, floating-leaved and submersed vegetation was 0.4, 0.3, and 0 kg wet wt/m^2, respectively (Table 3). The average epiphytic algal concentration associated with the aquatic macrophytes was 10.6 mg chlorophyll *a*/cm^2 of host plant and 9.2 mg chlorophyll *a*/kg wet wt of host plant (Table 3). Fourteen species of aquatic macrophytes were collected in Rowell. The most commonly encountered plant species were *Taxodium distichum, Alternanthera philoxeroides,* and *Pontederia cordata*, which occurred in 70%, 60%, and 50% of the transects, respectively (Table 174).

Table 174. Occurrence of plant species in ten evenly-spaced transects around Lake Rowell.

Common name	Scientific name	Percent of Transects
giant duckweed	*Spirodela polyrhiza*	10
floating water-hyacinth	*Eichhornia crassipes*	20
alligator-weed	*Alternanthera philoxeroides*	60
spatterdock	*Nuphar luteum*	10
smartweed	*Polygonum hydropiperoides*	40
pickerelweed	*Pontederia cordata*	50
cat-tail	*Typha* spp.	30
elephant-ear	*Colocasia esculenta*	20
water primrose	*Ludwigia octovalis*	40
buttonbush	*Cephalanthus occidentalis*	20
flat-sedge	*Cyperus odoratus*	10
para grass	*Brachiaria mutica*	20
knot grass	*Paspalum distichum*	10
bald cypress	*Taxodium distichum*	70

The plant community of Lake Rowell has been monitored by the Florida Department of Natural Resources from 1982 to present. The major aquatic plant in the lake during that time period was *Hydrilla verticillata,* which fluctuated dramatically from low levels (10 to 40% coverage) to high levels (80 to 90% coverage) every other year. This fluctuation was caused by herbicide treatments conducted by the Florida Department of Natural Resources.

Thus, the low levels of aquatic vegetation reported for this study (Table 3 and 174) are not indicative of the history of Lake Rowell. The fish population in Lake Rowell, therefore, can be considered the product of a hypereutrophic lake with dramatically fluctuating levels of aquatic vegetation.

Invertebrates

The average number and biomass of epiphytic macroinvertebrates in Rowell was 120 individuals/kg wet wt of host plant and 0.28 g wet wt/kg wet wt of host plant (Table 5). Average number and biomass of benthic macroinvertebrates in Rowell, as estimated with a ponar dredge, was 133 individuals/m^2 and 0.03 g wet wt/m^2 (Table 5). The zooplankton population in Lake Rowell was dominated by rotifers and cladocerans with 121,000 and 42,300 individuals/m^3, respectively (Table 5).

Fish

Thirty species of fish were collected from Lake Rowell (Table 175, 176 and 177). The most abundant species collected with rotenone sampling were threadfin shad and golden shiner. These species had average standing stocks in littoral blocknets of 55,100, and 24,100 fish/ha, respectively (Table 175). The most abundant open-water species collected in the experimental gillnets were gizzard shad and golden shiner with 160 and 22 fish/net/24 hr, respectively (Table 176). The most abundant species collected using electrofishing were the golden shiner, and threadfin shad with catch per unit efforts of 727 and 486 fish per hour, respectively (Table 177). Average first year growth of bluegill, redear sunfish, and largemouth bass was 64, 98, and 152 mm TL, respectively (Table 6). Mark-recapture estimates indicated that there were 233 harvestable bluegill, 143 harvestable redear sunfish, and 48 harvestable largemouth bass per hectare (Table 7) in Lake Rowell.

The fish population in Lake Rowell was sampled with rotenone and blocknets by the Florida Game and Fresh Water Fish Commission in 1974, 1977 and 1980 (Krummrich et al. 1980). The average total fish biomass ranged from 120 to 159 kg/ha during that time, which is significantly less then the values reported for this study (615 kg/ha for the littoral and 340 kg/ha for open-water; Table 175). The increase in standing crop of fish in Lake Rowell could have been the result of eutrophication **(Text continued on page 382)**

Table 175. Blocknet-rotenone estimates of total and harvestable fish stock (number/hectare) and standing crop (kg/hectare) for Lake Rowell. Mean values for littoral and open-water nets are listed by species with the corresponding standard error of the mean.

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Littoral nets (n=2) for total fish				
Florida gar	0	0	0.0	0.00
Bowfin	25	12	12.9	12.31
Gizzard shad	655	161	27.4	3.32
Threadfin shad	55087	36834	112.3	76.08
Chain pickerel	0	0	0.0	0.00
Golden shiner	24144	2902	94.0	5.84
Taillight shiner	62	37	0.0	0.01
Lake chubsucker	62	0	0.3	0.05
Yellow bullhead	68	6	14.8	1.61
Brown bullhead	290	6	1.7	0.46
Tadpole madtom	12	12	0.1	0.09
Golden topminnow	401	191	0.6	0.28
Lined topminnow	352	352	0.5	0.46
Bluefin killifish	6583	2927	1.8	0.60
Mosquitofish	2112	1470	1.6	1.07
Sailfin molly	117	117	0.2	0.16
Brook silverside	401	191	0.4	0.14
Pirate perch	117	117	0.7	0.70
Bluespotted sunfish	4137	2705	6.9	1.78
Warmouth	6274	1927	61.9	6.39
Bluegill	8324	2075	99.3	2.80
Redear sunfish	5397	2939	44.8	15.68
Spotted sunfish	3075	1025	52.9	21.42
Largemouth bass	253	117	63.1	34.88
Black crappie	5539	463	16.8	0.72
Swamp darter	352	142	0.2	0.02
Total	123839		615.2	

Table 175. (Continued)

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Open-water nets (n=2) for total fish				
Florida gar	6	6	4.2	4.18
Bowfin	0	0	0.0	0.00
Gizzard shad	2093	377	43.5	2.13
Threadfin shad	70858	13492	177.4	36.66
Chain pickerel	6	6	1.8	1.79
Golden shiner	56	43	2.8	2.77
Taillight shiner	19	19	0.0	0.02
Lake chubsucker	12	0	6.0	3.02
Yellow bullhead	0	0	0.0	0.00
Brown bullhead	0	0	0.0	0.00
Tadpole madtom	0	0	0.0	0.00
Golden topminnow	0	0	0.0	0.00
Lined topminnow	0	0	0.0	0.00
Bluefin killifish	0	0	0.0	0.00
Mosquitofish	0	0	0.0	0.00
Sailfin molly	0	0	0.0	0.00
Brook silverside	6	6	0.0	0.01
Pirate perch	0	0	0.0	0.00
Bluespotted sunfish	0	0	0.0	0.00
Warmouth	0	0	0.0	0.00
Bluegill	2402	364	52.9	2.96
Redear sunfish	531	148	38.2	15.22
Spotted sunfish	0	0	0.0	0.00
Largemouth bass	19	6	3.0	1.57
Black crappie	1352	735	7.7	5.71
Swamp darter	0	0	0.0	0.00
Total	77360		337.5	

Table 175. (Concluded)

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Littoral nets (n=2) for harvestable fish				
Chain pickerel	0	0.0	0.0	0.00
Yellow bullhead	49	12.3	13.9	2.02
Brown bullhead	0	0.0	0.0	0.00
Warmouth	68	6.2	8.4	0.25
Bluegill	241	80.3	22.2	6.88
Redear sunfish	105	6.2	12.5	2.80
Spotted sunfish	6	6.2	0.6	0.59
Largemouth bass	74	24.7	58.0	36.68
Black crappie	0	0.0	0.0	0.00
Total	543		115.6	
Open-water nets (n=2) for harvestable fish				
Chain pickerel	6	6.2	1.8	1.79
Yellow bullhead	0	0.0	0.0	0.00
Brown bullhead	0	0.0	0.0	0.00
Warmouth	0	0.0	0.0	0.00
Bluegill	290	18.5	32.2	2.57
Redear sunfish	191	105.0	26.2	12.90
Spotted sunfish	0	0.0	0.0	0.00
Largemouth bass	6	6.2	2.2	2.24
Black crappie	6	6.2	3.2	3.21
Total	500		65.6	

Table 176. Experimental gillnet (five 10-meter long sections of 1.9, 2.5, 3.8, 5.1, and 6.4 cm bar mesh, which were 2.4 meter deep) catch per unit effort estimates of total and harvestable fish number (number/net/24 hr) and weight (kg/net/24 hr) for Lake Rowell. Mean values for experimental gillnets are listed by species with the corresponding standard error of the mean.

Common Name	Fish number (number/net/24 hr)	Standard Error	Fish weight (kg/net/24 hr)	Standard Error
Gillnets (n=3) for total fish				
Florida gar	8.3	3.71	6.4	2.90
Longnose gar	3.0	1.53	8.4	4.26
Bowfin	1.3	0.88	1.9	1.24
Gizzard shad	160.0	27.47	18.7	4.03
Threadfin shad	17.7	8.95	0.5	0.25
Chain pickerel	1.7	0.33	0.6	0.14
Golden shiner	22.0	12.01	3.2	1.65
Lake chubsucker	4.0	1.00	1.6	0.66
Warmouth	0.3	0.33	0.0	0.04
Bluegill	1.0	0.58	0.1	0.07
Redear sunfish	0.7	0.67	0.1	0.08
Largemouth bass	6.7	2.96	1.7	0.85
Striped bass	0.3	0.33	0.1	0.11
Sunshine bass	3.7	0.33	2.9	0.38
Black crappie	0.7	0.33	0.1	0.05
Total	231.3		46.4	
Gillnets (n=3) for harvestable fish				
Chain pickerel	1.3	0.33	0.5	0.14
Warmouth	0.3	0.33	0.0	0.04
Bluegill	1.0	0.58	0.1	0.07
Redear sunfish	0.3	0.33	0.1	0.06
Largemouth bass	6.0	2.52	1.7	0.79
Sunshine bass	3.7	0.33	2.9	0.38
Black crappie	0.7	0.33	0.1	0.05
Total	13.3		5.4	

Table 177. Electrofishing catch per unit effort estimates of total and harvestable fish number (number/hr) and weight (kg/hr) for Lake Rowell. Mean values are listed by species with the corresponding standard error of the mean.

Common Name	Number (number/hr)	Standard Error	Weight (kg/hr)	Standard Error
Electrofishing runs (n=4) for total fish				
Florida gar	12.0	5.48	81.4	3.66
Bowfin	13.5	3.77	225.0	11.22
Gizzard shad	151.5	91.73	9.8	0.55
Threadfin shad	486.0	283.67	9.4	0.53
Golden shiner	727.5	208.04	24.1	0.83
Taillight shiner	3.0	1.73	0.0	0.00
Lake chubsucker	13.5	7.50	13.0	1.21
Seminole killifish	13.5	6.65	0.9	0.04
Bluefin killifish	6.0	4.24	0.10	0.01
Mosquitofish	3.0	1.73	0.10	0.01
Brook silverside	1.5	1.50	0.0	0.00
Bluespotted sunfish	4.5	2.87	0.1	0.01
Warmouth	22.5	12.82	12.0	0.58
Bluegill	433.5	65.88	135.8	6.84
Redear sunfish	136.5	43.57	23.6	0.72
Spotted sunfish	7.5	1.50	3.2	0.07
Largemouth bass	45.0	7.14	182.9	6.48
Black crappie	87.0	62.67	2.4	0.18
Total	2167.5		723.6	
Electrofishing runs (n=4) for harvestable fish				
Warmouth	4.5	2.87	0.5	0.31
Bluegill	63.0	37.99	7.2	4.95
Redear sunfish	4.5	2.87	0.5	0.37
Spotted sunfish	0.0	0.00	0.0	0.00
Largemouth bass	28.5	6.18	18.0	6.56
Black crappie	0.0	0.00	0.0	0.00
Total	100.5		26.3	

caused by the discharge of treated wastewater from the City of Starke or the invasion of hydrilla in 1976 and subsequent fluctuation of vegetation levels. The effluent discharged into Lake Rowell from the City of Starke in the early 1970's averaged 500,000 gallons per day and currently averages about 1,000,000 gallons per day. In 1969 and 1970, the chlorophyll *a* value in Lake Rowell averaged 22 µg/L (Duchrow 1970), which is about half the value reported for this study (47 µg/L; Table 2). Thus, it seems the fish population in Lake Rowell has changed significantly over the last 20 years.

Lochloosa

Location and Morphology

Lochloosa is located in Alachua County, Florida (Latitude 29.31 N; Longitude 82.08 W). The lake lies in the Alachua Prairies subdivision of the Northern Peninsual Plains division of the Ocala Uplift District (Brooks 1981). The geology is dominated by sand, silty sand, and phosphatic clays of the Hawthorne Formation. Lochloosa was sampled from 1988 to 1989 and had a surface area, shoreline length, and mean depth of 2309 ha, 22.6 km and 1.8 m, respectively (Table 1).

Trophic Status and Water Chemistry

Lochloosa had an average total phosphorus concentration of 32 µg/L and an average total nitrogen concentration of 1053 µg/L. Total chlorophyll *a* concentrations averaged 22 µg/L and the water clarity as measured by use of a Secchi disc averaged 1 m (Table 2). The lake had an average pH of 8.1 and an average total alkalinity of 25 mg/L as $CaCO_3$. The average specific conductance was 96 µS/cm @ 25 C and the average water color was 116 Pt-Co units. The adjusted chlorophyll *a* value for Lochloosa was 45.3 µg/L. Using this value and the classification system of Forsberg and Ryding (1980), Lochloosa was classified as a hypereutrophic lake during this study.

Aquatic Plants

Lochloosa had a high abundance of aquatic macrophytes with a percent area coverage (PAC) and percent volume infested (PVI) with aquatic macrophytes of 83% and 57%, respectively (Table 3). The average above-ground biomass of emergent, floating-leaved and submersed vegetation was 2.2, 0.6, and 2.6 kg wet wt/m^2, respectively (Table 3). The average epiphytic algal concentration associated with the aquatic macrophytes was 12.5 mg chlorophyll *a*/cm^2 of host plant, and 32 mg chlorophyll *a*/kg wet wt of host plant (Table 3). Fifteen species of aquatic macrophytes were collected from Lochloosa. The most commonly encountered plant species were *Hydrilla verticillata, Paspalum distichum,* and Taxodium *distichum*, which occurred in 100%, 90%, and 90% of the transects, respectively (Table 178).

Table 178. Occurrence of plant species in ten evenly-spaced transects around Lake Lochloosa.

Common name	Scientific name	Percent of Transect
water-lettuce	*Pistia stratiotes*	20
common duckweed	*Lemna minor*	30
floating water-hyacinth	*Eichhornia crassipes*	60
azolla	*Azolla caroliniana*	10
common salvinia	*Salvinia rotundifolia*	40
alligator-weed	*Alternanthera philoxeroides*	20
spatterdock	*Nuphar luteum*	20
pickerelweed	*Pontederia cordata*	40
water-pennywort	*Hydrocotyle umbellata*	20
coontail	*Ceratophyllum demersum*	50
hydrilla	*Hydrilla verticillata*	100
southern naiad	*Najas guadalupensis*	20
elephant-ear	*Colocasia esculenta*	40
knot grass	*Paspalum distichum*	90
bald cypress	*Taxodium distichum*	90

The plant community of Lochloosa has been monitored by the Florida Department of Natural Resources from 1982 to present. The major plant during that time was *Hydrilla verticillata*, which is similar to our plant sampling (Table 3 and Table 178). The percent lake area covered with hydrilla fluctuated greatly during that time ranging from 5% to 90%. The fluctuations were determined by aquatic herbicide treatments conducted by the Florida Department of Natural Resources. Thus, the fish population in Lochloosa can be considered the product of a hypereutrophic lake with high levels of fluctuating aquatic vegetation.

Invertebrates

The average number and biomass of epiphytic macroinvertebrates in Lochloosa was 34 individuals/kg wet wt of host plant and 0.22 g wet wt/kg wet wt of host plant (Table 5). Average number and biomass of benthic macroinvertebrates in Lochloosa, as estimated with a ponar dredge, was 207 individuals/m^2 and 0.20 g wet wt/m^2 (Table 5). The zooplankton population in Lochloosa was dominated by rotifers and cladocerans with 126,000 and 53,700 individuals/m^3, respectively (Table 5).

Fish

Twenty-nine species of fish were collected in Lochloosa (Table 179, 180 and 181). The most abundant species collected with rotenone sampling were brown bullhead and bluespotted sunfish. These species had average standing stocks in littoral blocknets of 7,500 and 7,100 fish/ha, respectively (Table 179). The most abundant open-water species collected in the experimental gillnets were gizzard shad, and largemouth bass with 47 and 18 fish/net/24 hr, respectively (Table 180). The most abundant species collected using electrofishing were threadfin shad and bluegill with catch per unit efforts of 761, and 132 fish per hour, respectively (Table 181). Average first year growth of bluegill, redear sunfish, and largemouth bass was 65, 57, and 148 mm TL, respectively (Table 6). Mark-recapture estimates indicated that there were 17 harvestable largemouth bass per hectare in Lochloosa Lake (Table 7).

The Florida Game and Fresh Water Fish Commission has sampled the fish population in Lochloosa with rotenone and blocknets six times between 1975 and 1990. The total and harvestable fish biomass ranged 80 to 410 kg/ha and 26 to 115 kg/ha, respectively. This considerable range in fish biomass seems to be the result of large fluctuations in vegetation.

Turkey Pen

Location and Morphology

Turkey Pen is located in Calhoun County, Florida (Latitude 30.33 N; Longitude 85.17 W). The lake lies in the Betts Delta subdivision of the Paleodelta Relics division of the Apalachicola Delta District (Brooks 1981). The geology is dominated by gravel, sand, and micaceous kaolinitic clays of the Citronelle Formation. Turkey Pen was sampled from 1988 to 1989 and had a surface area, shoreline length, **(Text continued on page 390)**

Table 179. Blocknet-rotenone estimates of total and harvestable fish stock (number/hectare) and standing crop (kg/hectare) for Lochloosa. Mean values for littoral and open-water nets are listed by species with the corresponding standard error of the mean.

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Littoral nets (n=3) for total fish				
Florida gar	8	8	3.9	3.91
Bowfin	37	26	26.1	16.99
Gizzard shad	0	0	0.0	0.00
Threadfin shad	2384	2153	5.3	4.90
Chain pickerel	21	21	2.7	2.70
Golden shiner	33	33	0.1	0.15
Taillight shiner	91	67	0.1	0.04
Lake chubsucker	292	256	1.9	1.55
Yellow bullhead	440	230	2.0	1.01
Brown bullhead	7513	3909	25.9	14.94
White catfish	403	310	1.4	1.04
Golden topminnow	795	398	0.9	0.47
Seminole killifish	49	38	0.3	0.27
Bluefin killifish	3528	1190	1.2	0.11
Mosquitofish	4306	2464	1.7	0.97
Least killifish	301	178	0.1	0.04
Sailfin molly	333	333	0.5	0.52
Brook silverside	0	0	0.0	0.00
Pirate perch	8	4	0.1	0.04
Bluespotted sunfish	7097	3444	4.9	2.42
Warmouth	5105	2295	29.6	9.38
Bluegill	963	612	11.7	10.55
Redear sunfish	4936	1174	21.4	5.12
Spotted sunfish	58	41	0.4	0.24
Largemouth bass	1095	413	12.3	7.18
Black crappie	527	209	5.2	2.51
Swamp darter	86	86	0.1	0.09
Flier	156	156	0.6	0.63
Total	40566		160.4	

Table 179. (Continued)

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Open-water nets (n=3) for total fish				
Florida gar	4	4	2.8	2.79
Bowfin	0	0	0.0	0.00
Gizzard shad	33	11	16.4	6.50
Threadfin shad	9925	8016	8.6	5.84
Chain pickerel	0	0	0.0	0.00
Golden shiner	0	0	0.0	0.00
Taillight shiner	136	93	0.1	0.05
Lake chubsucker	4	4	2.8	2.83
Yellow bullhead	0	0	0.0	0.00
Brown bullhead	0	0	0.0	0.00
White catfish	0	0	0.0	0.00
Golden topminnow	0	0	0.0	0.00
Seminole killifish	4	4	0.0	0.03
Bluefin killifish	4	4	0.0	0.00
Mosquitofish	0	0	0.0	0.00
Least killifish	0	0	0.0	0.00
Sailfin molly	0	0	0.0	0.00
Brook silverside	4	4	0.0	0.00
Pirate perch	0	0	0.0	0.00
Bluespotted sunfish	0	0	0.0	0.00
Warmouth	0	0	0.0	0.00
Bluegill	301	224	29.5	28.41
Redear sunfish	362	356	13.4	13.19
Spotted sunfish	0	0	0.0	0.00
Largemouth bass	45	21	9.2	8.86
Black crappie	8	8	1.5	1.52
Swamp darter	4	4	0.0	0.00
Flier	0	0	0.0	0.00
Total	10835		84.4	

Table 179. (Concluded)

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Littoral nets (n=3) for harvestable fish				
Chain pickerel	4	4.1	1.7	1.70
Yellow bullhead	0	0.0	0.0	0.00
Brown bullhead	0	0.0	0.0	0.00
White catfish	0	0.0	0.0	0.00
Warmouth	62	12.4	7.6	1.93
Bluegill	12	12.4	2.3	2.33
Redear sunfish	4	4.1	1.3	1.31
Spotted sunfish	0	0.0	0.0	0.00
Largemouth bass	12	12.4	7.9	7.86
Black crappie	0	0.0	0.0	0.00
Flier	0	0.0	0.0	0.00
Total	95		20.8	
Open-water nets (n=3) for harvestable fish				
Chain pickerel	0	0.0	0.0	0.00
Yellow bullhead	0	0.0	0.0	0.00
Brown bullhead	0	0.0	0.0	0.00
White catfish	0	0.0	0.0	0.00
Warmouth	0	0.0	0.0	0.00
Bluegill	115	115.3	24.7	24.70
Redear sunfish	33	32.9	7.2	7.24
Spotted sunfish	0	0.0	0.0	0.00
Largemouth bass	21	20.6	8.7	8.72
Black crappie	4	4.1	1.5	1.49
Flier	0	0.0	0.0	0.00
Total	173		42.2	

Table 180. Experimental gillnet (five 10-meter long sections of 1.9, 2.5, 3.8, 5.1, and 6.4 cm bar mesh, which were 2.4 meter deep) catch per unit effort estimates of total and harvestable fish number (number/net/24 hr) and weight (kg/net/24 hr) for Lochloosa. Mean values for experimental gillnets are listed by species with the corresponding standard error of the mean.

Common Name	Fish number (number/net/24 hr)	Standard Error	Fish weight (kg/net/24 hr)	Standard Error
Gillnets (n=3) for total fish				
Florida gar	3.0	1.00	2.2	0.38
Bowfin	1.0	1.00	1.4	1.45
Gizzard shad	46.7	7.51	19.6	3.01
Golden shiner	0.3	0.33	0.0	0.01
Bluegill	2.7	1.20	0.6	0.27
Redear sunfish	2.0	1.15	0.3	0.13
Largemouth bass	18.3	5.90	1.6	0.80
Sunshine bass	1.7	0.33	2.1	0.52
Black crappie	2.0	0.58	0.1	0.08
Total	77.7		28.0	
Gillnets (n=3) for harvestable fish				
Bluegill	2.7	1.20	0.6	0.27
Redear sunfish	1.0	0.58	0.2	0.13
Largemouth bass	1.7	1.20	0.8	0.52
Sunshine bass	1.7	0.33	2.1	0.52
Black crappie	0.3	0.33	0.1	0.08
Total	7.3		3.8	

Table 181. Electrofishing catch per unit effort estimates of total and harvestable fish number (number/hr) and weight (kg/hr) for Lochloosa. Mean values are listed by species with the corresponding standard error of the mean.

Common Name	Number (number/hr)	Standard Error	Weight (kg/hr)	Standard Error
Electrofishing runs (n=6) for total fish				
Florida gar	19.0	7.16	101.5	4.40
Bowfin	13.0	3.27	134.6	4.17
Gizzard shad	1.0	1.00	4.4	0.44
Threadfin shad	761.0	188.87	9.9	0.26
Chain pickerel	6.0	2.68	38.6	1.88
Golden shiner	6.0	3.11	1.0	0.06
Taillight shiner	48.0	48.00	0.4	0.04
Lake chubsucker	17.0	5.89	105.8	3.54
Golden topminnow	2.0	2.00	0.0	0.00
Seminole killifish	1.0	1.00	0.1	0.01
Bluefin killifish	2.0	1.29	0.0	0.00
Mosquitofish	4.0	2.00	0.0	0.00
Brook silverside	5.0	1.00	0.0	0.00
Bluespotted sunfish	2.0	2.00	0.0	0.00
Warmouth	3.0	2.04	1.3	0.12
Bluegill	132.0	55.79	36.2	2.59
Redear sunfish	40.0	11.14	9.2	0.41
Spotted sunfish	1.0	1.00	0.0	0.00
Largemouth bass	72.0	9.55	99.0	3.29
Black crappie	2.0	1.29	0.7	0.07
Swamp darter	1.0	1.00	0.0	0.00
Total	1138.0		542.8	

Table 181. (Concluded)

Common Name	Number (number/hr)	Standard Error	Weight (kg/hr)	Standard Error
Electrofishing runs (n=6) for harvestable fish				
Chain pickerel	6.0	2.68	3.9	1.88
Warmouth	1.0	1.00	0.1	0.12
Bluegill	10.0	7.85	2.8	2.35
Redear sunfish	3.0	1.34	0.8	0.36
Spotted sunfish	0.0	0.00	0.0	0.00
Largemouth bass	18.0	6.39	9.4	3.29
Black crappie	0.0	0.00	0.0	0.00
Total	38.0		17.0	

and mean depth of 6 ha, 0.89 km and 5 m, respectively (Table 1).

Trophic Status and Water Chemistry

Turkey Pen had an average total phosphorus concentration of 1 µg/L and an average total nitrogen concentration of 132 µg/L. Total chlorophyll *a* concentrations averaged 1 µg/L and the water clarity as measured by use of a Secchi disc averaged 3.2 m (Table 2). The lake had an average pH of 4.7 and an average total alkalinity of 0.4 mg/L as $CaCO_3$. The average specific conductance was 21 µS/cm @ 25 C and the average water color was 1 Pt-Co units. Using the classification system of Forsberg and Ryding (1980), Turkey Pen was classified as an oligotrophic lake.

Aquatic Plants

Turkey Pen had a low abundance of aquatic macrophytes with a percent area coverage (PAC) and percent volume infested (PVI) with aquatic macrophytes of 17% and 3%, respectively (Table 3). The average above-ground biomass of emergent, floating-leaved and submersed vegetation was 0.2, 0 and 0.1 kg wet wt/m^2, respectively (Table 3). The average epiphytic algal concentration associated with the aquatic macrophytes was 17.1 mg chlorophyll *a*/cm^2 of host plant and 24.9 mg chlorophyll *a*/kg wet wt of host plant (Table 3). Four species of aquatic macrophytes were collected in Turkey Pen. The most commonly encountered plant species were *Hypericum* spp., *Panicum hemitomon,* and Utricularia *floridana*, which occurred in 100%, 60%, and 40% of the transects, respectively (Table 182).

Table 182. Occurrence of plant species in ten evenly-spaced transects around Turkey Pen.

Common name	Scientific name	Percent of Transects
maidencane	*Panicum hemitomon*	60
	Utricularia floridana	40
pipewort	*Eriocaulon* spp.	10
St. John's wort	*Hypericum* spp.	100

No previous vegetation studies have been conducted on Turkey Pen, but the lake is isolated and located on undeveloped land. We, therefore, believe that no major change in the aquatic vegetation would be expected. Thus, the fish population in Turkey Pen can be considered the product of an oligotrophic lake with low levels of aquatic vegetation.

Invertebrates

The average number and biomass of epiphytic macroinvertebrates in Turkey Pen was 253 individuals/kg wet wt of host plant and 0.37 g wet wt/kg wet wt of host plant (Table 5). Average number and biomass of benthic macroinvertebrates in Turkey Pen, as estimated with a ponar dredge, was 533 individuals/m^2 and 1.40 g wet wt/m^2 (Table 5). The zooplankton population in Turkey Pen was dominated by nauplii and cladocerans, with 23,600 and 15,400 individuals/m^3, respectively (Table 5).

Fish

Ten species of fish were collected from Turkey Pen (Table 183, 184 and 185). The most abundant species collected with rotenone sampling were warmouth and bluegill. These species had average standing stocks in littoral blocknets of 5,100 and 750 fish/ha, respectively (Table 183). The most abundant open-water species collected in the experimental gillnets were bluegill and largemouth bass with 3.3 and 3.0 fish/net/24 hr, respectively (Table 184). The most abundant species collected using electrofishing were lake chubsucker and lined topminnow with catch per unit efforts of 14.4 and 11.4 fish per hour, respectively (Table 185). Average first year growth of bluegill, redear sunfish, and largemouth bass was 47, 77, and 108 mm TL, respectively (Table 6). Mark-recapture estimates indicated that there were 2 harvestable bluegill per hectare in Turkey Pen (Table 7).

No previous fisheries studies have been conducted on Turkey Pen. However, Turkey Pen is an isolated lake on undeveloped land and no major change in the fish population would be expected.

Fish Lake

Location and Morphology

Fish Lake is located in Osceola County, Florida (Latitude 28.16 N; Longitude 81.2 W). The lake lies in the Kissimmee Valley division of the Eastern Flatwoods District (Brooks 1981). The geology is dominated by lagoonal deposits of unlithified silty sands. Fish Lake was sampled from 1988 to 1989 and had a surface area, shoreline length, and mean depth of 89 ha, 4.01 km and 1.9 m, respectively (Table 1).

Trophic Status and Water Chemistry

Fish Lake had an average total phosphorus concentration of 25 µg/L and an average total nitrogen concentration of 935 µg/L. Total chlorophyll *a* concentrations averaged 18 µg/L and the water clarity as measured by use of a Secchi disc averaged 1 m (Table 2). The lake had an average pH of 7.6 and an average total alkalinity of 25.9 mg/L as $CaCO_3$. The average specific conductance was 187 µS/cm @ 25 C and the average water color was 43 Pt-Co units. The adjusted chlorophyll a value for Fish Lake was 19.4 µg/L. Using this value and the classification system of Forsberg and Ryding (1980), Fish Lake was classified as an eutrophic lake. **(Text continued on page 196)**

Table 183. Blocknet-rotenone estimates of total and harvestable fish stock (number/hectare) and standing crop (kg/hectare) for Turkey Pen. Mean values for littoral and open-water nets are listed by species with the corresponding standard error of the mean.

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Littoral nets (n=2) for total fish				
Lake chubsucker	247	173	13.7	8.89
Yellow bullhead	25	25	0.8	0.79
Golden topminnow	19	19	0.0	0.02
Lined topminnow	105	105	0.1	0.11
Mosquitofish	12	12	0.0	0.01
Brook silverside	56	56	0.1	0.06
Everglades pygmy sunfish	445	309	0.1	0.04
Warmouth	5057	994	19.2	4.94
Bluegill	747	56	11.5	0.46
Largemouth bass	99	25	25.2	13.99
Total	6811		70.7	
Open-water nets (n=1) for total fish				
Lake chubsucker	25	0	2.1	0.00
Yellow bullhead	0	0	0.0	0.00
Golden topminnow	0	0	0.0	0.00
Lined topminnow	0	0	0.0	0.00
Mosquitofish	0	0	0.0	0.00
Brook silverside	25	0	0.0	0.00
Everglades pygmy sunfish	0	0	0.0	0.00
Warmouth	161	0	0.3	0.00
Bluegill	2754	0	34.0	0.00
Largemouth bass	25	0	1.5	0.00
Total	2989		37.9	

Table 183. (Concluded)

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Littoral nets (n=2) for harvestable fish				
Yellow bullhead	0	0.0	0.0	0.00
Warmouth	6	6.2	0.6	0.63
Bluegill	6	6.2	0.5	0.49
Largemouth bass	31	6.2	22.9	14.47
Total	43		24.1	
Open-water nets (n=1) for harvestable fish				
Yellow bullhead	0	0.0	0.0	0.00
Warmouth	0	0.0	0.0	0.00
Bluegill	0	0.0	0.0	0.00
Largemouth bass	0	0.0	0.0	0.00
Total	0		0.0	

Table 184. Experimental gillnet (five 10-meter long sections of 1.9, 2.5, 3.8, 5.1, and 6.4 cm bar mesh, which were 2.4 meter deep) catch per unit effort estimates of total and harvestable fish number (number/net/24 hr) and weight (kg/net/24 hr) for Turkey Pen. Mean values for experimental gillnets are listed by species with the corresponding standard error of the mean.

Common Name	Fish number (number/net/24 hr)	Standard Error	Fish weight (kg/net/24 hr)	Standard Error
Gillnets (n=3) for total fish				
Lake chubsucker	1.7	0.67	0.3	0.01
Warmouth	0.3	0.33	0.0	0.00
Bluegill	3.3	1.76	0.1	0.04
Largemouth bass	3.0	1.15	0.4	0.25
Total	8.3		0.7	
Gillnets (n=3) for harvestable fish				
Warmouth	0.0	0.00	0.0	0.00
Bluegill	0.0	0.00	0.0	0.00
Largemouth bass	0.3	0.33	0.2	0.22
Total	0.3		0.2	

Table 185. Electrofishing catch per unit effort estimates of total and harvestable fish number (number/hr) and weight (kg/hr) for Turkey Pen. Mean values are listed by species with the corresponding standard error of the mean.

Common Name	Number (number/hr)	Standard Error	Weight (kg/hr)	Standard Error
Electrofishing runs (n=4) for total fish				
Lake chubsucker	14.4	3.39	10.8	0.25
Lined topminnow	11.4	4.39	0.1	0.00
Warmouth	3.0	1.73	0.2	0.01
Bluegill	6.0	3.46	5.8	0.54
Largemouth bass	7.5	3.77	39.8	3.51
Total	42.2		56.6	
Electrofishing runs (n=4) for harvestable fish				
Warmouth	0.0	0.00	0.0	0.00
Bluegill	3.0	3.00	0.6	0.55
Largemouth bass	3.0	1.73	3.9	3.53
Total	6.0		4.5	

Aquatic Plants

Fish Lake had a low abundance of aquatic macrophytes with a percent area coverage (PAC) and percent volume infested (PVI) with aquatic macrophytes of 3.3% and 1.4%, respectively (Table 3). The average above-ground biomass of emergent, floating-leaved and submersed vegetation was 0.9, 1 and 0 kg wet wt/m^2, respectively (Table 3). The average epiphytic algal concentration associated with the aquatic macrophytes was 23.1 mg chlorophyll *a*/cm^2 of host plant and 20.1 mg chlorophyll *a*/kg wet wt of host plant (Table 3). Seventeen species of aquatic macrophytes were collected from Fish Lake. The most commonly encountered plant species were *Typha* spp., *Pistia stratiotes* and *Eichhornia crassipes*, which occurred in 80%, 70%, and 50% of the transects, respectively (Table 186).

The plant community of Fish Lake has been monitored by the Florida Department of

Table 186. Occurrence of plant species in ten evenly-spaced transects around Fish Lake.

Common name	Scientific name	Percent of Transects
water-lettuce	*Pistia stratiotes*	70
common duckweed	*Lemna minor*	10
floating water-hyacinth	*Eichhornia crassipes*	50
common salvinia	*Salvinia rotundifolia*	10
duck-potato	*Sagittaria lancifolia*	10
alligator-weed	*Alternanthera philoxeroides*	20
slender spikerush	*Eleocharis baldwinii*	10
smartweed	*Polygonum hydropiperoides*	10
pickerelweed	*Pontederia cordata*	20
cat-tail	*Typha* spp.	80
water-pennywort	*Hydrocotyle umbellata*	10
water primrose	*Ludwigia octovalis*	20
flat-sedge	*Cyperus odoratus*	10
giant bulrush	*Scirpus californicus*	10
maidencane	*Panicum hemitomon*	20
para grass	*Brachiaria mutica*	10
torpedograss	*Panicum repens*	30

Natural Resources from 1982 to present. In 1982 and 1983, the dominant plant was *Hydrilla verticillata* reaching a surface area coverage of 70%. In 1985, only a trace of hydrilla was found and since then *Typha* spp. has been the dominant species only covering 1 to 5% of the lake surface area. Thus, the fish population in Fish Lake can be considered the product of an eutrophic lake where a large decrease in aquatic vegetation has recently occurred.

Invertebrates

The average number and biomass of epiphytic macroinvertebrates in Fish Lake was 491 individuals/kg wet wt of host plant and 0.99 g wet wt/kg wet wt of host plant (Table 5).

Average number and biomass of benthic macroinvertebrates in Fish Lake, as estimated with a ponar dredge, was 1,433 individuals/m^2 and 32.13 g wet wt/m^2 (Table 5). The zooplankton population in Fish Lake was dominated by cladocerans and rotifers with 92,800 and 85,600 individuals/m^3, respectively (Table 5).

<u>Fish</u>

Twenty-one species of fish were collected from Fish Lake (Table 187, 188 and 189). The most abundant species collected with rotenone sampling were bluegill and warmouth. These species had average standing stocks in littoral blocknets of 7,000 and 1,200 fish/ha, respectively (Table 187). The most abundant open-water species collected in the experimental gillnets were threadfin shad and gizzard shad with 81 and 57 fish/net/24 hr, respectively (Table 188). The most abundant species collected using electrofishing were bluegill and largemouth bass with catch per unit efforts of 334 and 104 fish per hour, respectively (Table 189). Average first year growth of bluegill, redear sunfish and largemouth bass was 63, 61 and 152 mm TL, respectively (Table 6). Mark-recapture estimates indicated that there were 225 harvestable bluegill, 14 harvestable redear sunfish, and 17 harvestable largemouth bass per hectare in Fish Lake (Table 7).

The fish population of Fish Lake was sampled with rotenone and blocknets in 1967 and 1973 by the Florida Game and Fresh Water Fish Commission (Schneider at al. 1973). The sampling in 1973 was done to determine if a viable fish population existed in Fish Lake after an extensive illegal dredge and fill operation was conducted on the lake after 1967. The total standing crop of fish in 1967 averaged 255 kg/ha and 43 kg/ha in 1973. This decrease standing crop in Fish Lake from 1967 to 1973 was attributed to the illegal dredge and fill operation (Schneider at al. 1973). The total fish standing crop in littoral blocknets reported for this study averaged 210 kg/ha (Table 187), which is similar to the values prior to the dredge and fill operation. This suggests that the fish population in Fish Lake may have stabilized after the dredging operation. **(Text continued on page 403)**

Table 187. Blocknet-rotenone estimates of total and harvestable fish stock (number/hectare) and standing crop (kg/hectare) for Fish Lake. Mean values for littoral and open-water nets are listed by species with the corresponding standard error of the mean.

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Littoral nets (n=3) for total fish				
Bowfin	16	8	12.5	6.36
Gizzard shad	119	54	24.8	12.46
Threadfin shad	115	69	1.3	0.66
Golden shiner	8	8	0.1	0.09
Taillight shiner	4	4	0.0	0.00
Lake chubsucker	41	35	8.3	7.91
Tadpole madtom	247	129	0.5	0.30
Seminole killifish	70	32	0.2	0.16
Bluefin killifish	498	369	0.1	0.09
Brook silverside	305	195	0.3	0.22
Bluespotted sunfish	82	82	0.1	0.10
Warmouth	1214	523	24.8	11.53
Bluegill	6994	1464	71.2	14.66
Dollar sunfish	62	62	0.1	0.13
Redear sunfish	572	231	24.1	8.49
Spotted sunfish	62	38	1.4	0.88
Largemouth bass	358	86	39.4	10.76
Black crappie	0	0	0.0	0.00
Swamp darter	8	8	0.0	0.01
Blue tilapia	8	8	0.5	0.48
Total	10786		209.8	
Littoral nets (n=3) for harvestable fish				
Warmouth	66	32.9	7.4	3.77
Bluegill	268	76.9	27.3	8.08
Dollar sunfish	0	0.0	0.0	0.00
Redear sunfish	62	12.4	8.4	1.97
Spotted sunfish	0	0.0	0.0	0.00
Largemouth bass	74	18.9	22.4	6.51
Black crappie	0	0.0	0.0	0.00
Total	469		65.6	

Table 187. (Concluded)

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Open-water nets (n=3) for total fish				
Bowfin	0	0	0.0	0.00
Gizzard shad	193	126	19.0	8.13
Threadfin shad	6879	5879	37.3	30.37
Golden shiner	0	0	0.0	0.00
Taillight shiner	95	89	0.1	0.07
Lake chubsucker	0	0	0.0	0.00
Tadpole madtom	0	0	0.0	0.00
Seminole killifish	0	0	0.0	0.00
Bluefin killifish	0	0	0.0	0.00
Brook silverside	16	11	0.0	0.01
Bluespotted sunfish	0	0	0.0	0.00
Warmouth	0	0	0.0	0.00
Bluegill	733	229	17.6	8.53
Dollar sunfish	0	0	0.0	0.00
Redear sunfish	226	146	11.2	6.69
Spotted sunfish	0	0	0.0	0.00
Largemouth bass	82	25	21.9	15.81
Black crappie	37	31	8.0	7.63
Swamp darter	0	0	0.0	0.00
Blue tilapia	0	0	0.0	0.00
Total	8262		115.1	
Open-water nets (n=3) for harvestable fish				
Warmouth	0	0.0	0.0	0.00
Bluegill	86	80.4	9.2	8.24
Dollar sunfish	0	0.0	0.0	0.00
Redear sunfish	29	14.8	5.1	2.57
Spotted sunfish	0	0.0	0.0	0.00
Largemouth bass	37	31.1	18.4	16.73
Black crappie	33	32.9	7.8	7.76
Total	185		40.4	

Table 188. Experimental gillnet (five 10-meter long sections of 1.9, 2.5, 3.8, 5.1, and 6.4 cm bar mesh, which were 2.4 meter deep) catch per unit effort estimates of total and harvestable fish number (number/net/24 hr) and weight (kg/net/24 hr) for Fish Lake. Mean values for experimental gillnets are listed by species with the corresponding standard error of the mean.

Common Name	Fish number (number/net/24 hr)	Standard Error	Fish weight (kg/net/24 hr)	Standard Error
Gillnets (n=3) for total fish				
Florida gar	1.0	0.58	1.4	0.96
Gizzard shad	57.3	5.24	18.6	2.03
Threadfin shad	81.3	13.96	2.3	0.36
Golden shiner	3.7	1.33	0.4	0.19
Lake chubsucker	1.0	0.58	0.3	0.21
Bluegill	0.7	0.33	0.0	0.01
Largemouth bass	2.7	1.76	0.6	0.41
Black crappie	4.0	2.00	0.4	0.09
Total	151.7		24.1	
Gillnets (n=3) for harvestable fish				
Bluegill	0.0	0.00	0.0	0.00
Largemouth bass	1.3	0.88	0.5	0.34
Black crappie	1.3	0.33	0.2	0.05
Total	2.7		0.7	

Table 189. Electrofishing catch per unit effort estimates of total and harvestable fish number (number/hr) and weight (kg/hr) for Fish Lake. Mean values are listed by species with the corresponding standard error of the mean.

Common Name	Number (number/hr)	Standard Error	Weight (kg/hr)	Standard Error
Electrofishing runs (n=5) for total fish				
Florida gar	3.6	2.41	33.0	2.03
Bowfin	2.4	1.48	57.1	3.87
Golden shiner	13.2	11.76	3.0	0.19
Taillight shiner	1.2	1.18	0.0	0.00
Lake chubsucker	34.8	19.48	113.5	5.95
Seminole killifish	4.8	2.24	0.6	0.03
Brook silverside	2.4	1.48	0.0	0.00
Warmouth	1.2	1.18	0.0	0.00
Bluegill	333.6	73.55	74.4	1.32
Redear sunfish	63.6	10.50	21.2	0.44
Largemouth bass	104.4	16.61	146.8	3.64
Total	565.2		449.6	
Electrofishing runs (n=5) for harvestable fish				
Warmouth	0.0	0.00	0.0	0.00
Bluegill	16.8	6.41	1.9	0.79
Redear sunfish	8.4	3.06	0.9	0.41
Largemouth bass	20.4	6.18	9.6	3.19
Total	45.6		12.3	

Pond is a private lake on undeveloped land and the owner (Mr. Jack Williams of Gainesville, Florida) and his land caretaker both agree the lake's vegetation and general appearance has remained the same for several years prior to our sampling. Thus, the fish population in Bull Pond can be considered the product of a mesotrophic lake with a low to moderate level of aquatic vegetation.

Table 190. Occurrence of plant species in ten evenly-spaced transects around Bull Pond.

Common name	Scientific name	Percent of Transects
slender spikerush	*Eleocharis baldwinii*	60
banana-lily	*Nymphoides aquatica*	100
spatterdock	*Nuphar luteum*	90
red ludwigia	*Ludwigia repens*	10
pickerelweed	*Pontederia cordata*	40
cone-spur bladderwort	*Utricularia gibba*	20
buttonbush	*Cephalanthus occidentalis*	100
maidencane	*Panicum hemitomon*	100
para grass	*Brachiaria mutica*	30
	Fuirena sciropoidea	20
	Leersia hexandra	60
St. John's wort	*Hypericum* spp.	100

Invertebrates

The average number and biomass of epiphytic macroinvertebrates in Bull Pond was 96 individuals/kg wet wt of host plant and 0.08 g wet wt/kg wet wt of host plant (Table 5). Average number and biomass of benthic macroinvertebrates in Bull Pond, as estimated with a ponar dredge, was 640 individuals/m^2 and 4.07 g wet wt/m^2 (Table 5). The zooplankton population in Bull Pond was dominated by rotifers and nauplii with 110,000 and 77,500 individuals/m^3, respectively (Table 5).

Fish

Twenty-two species of fish were collected from Bull Pond (Table 191, 192 and 193). The most abundant species collected with rotenone sampling were bluegill and warmouth. These species had average standing stocks in littoral blocknets of 10,600 and 6,100 fish/ha,

Bull Pond

Location and Morphology

Bull Pond is located in Putnam County, Florida (Latitude 29.31 N; Longitude 81.58 W). The lake lies in the St. Johns Offset division of the Central Lake District (Brooks 1981). The geology is dominated by deeply weathered clayey sand and granular sand of the Hawthorne Formation. Bull Pond was sampled from 1989 to 1990 and had a surface area, shoreline length, and mean depth of 11 ha, 1.38 km and 2.3 m, respectively (Table 1).

Trophic Status and Water Chemistry

Bull Pond had an average total phosphorus concentration of 11 µg/L and an average total nitrogen concentration of 522 µg/L. Total chlorophyll *a* concentrations averaged 3 µg/L and the water clarity as measured by use of a Secchi disc averaged 1.4 m (Table 2). The lake had an average pH of 5.3 and an average total alkalinity of 0.7 mg/L as $CaCO_3$. The average specific conductance was 57 µS/cm @ 25 C and the average water color was 9 Pt-Co units. The adjusted chlorophyll *a* value for Bull Pond was 3.5 µg/L. Using the classification system of Forsberg and Ryding (1980), Bull pond was classified as a mesotrophic lake.

Aquatic Plants

Bull Pond had a moderate abundance of aquatic macrophytes with a percent area coverage (PAC) and percent volume infested (PVI) with aquatic macrophytes of 20% and 11%, respectively (Table 3). The average above-ground biomass of emergent, floating-leaved and submersed vegetation was 1.8, 0.3, and 0 kg wet wt/m^2, respectively (Table 3). The average epiphytic algal concentration associated with the aquatic macrophytes was 33.8 mg chlorophyll *a*/cm^2 of host plant and 17 mg chlorophyll *a*/kg wet wt of host plant (Table 3). Twelve species of aquatic macrophytes were collected in Bull Pond. The most commonly encountered plant species were *Nymphoides aquatica, Cephalanthus occidentalis,* and *Panicum hemitomon,* which occurred in 100%, 100%, and 100% of the transects, respectively (Table 190).

No previous vegetation studies have been conducted on Bull Pond. However, Bull respectively (Table 191). The most abundant open-water species collected in the experimental gillnets were Florida gar and lake chubsucker with 7.3 and 4 fish/net/24 hr, respectively (Table 192). The most abundant species collected using electrofishing were the largemouth bass and Florida gar with catch per unit efforts of 42 and 36 fish per hour, respectively (Table 193). Average first year growth of bluegill, redear sunfish, and largemouth bass was 53, 52, and 142 mm TL, respectively (Table 6). Mark-recapture estimates indicated that there were 31 harvestable bluegill, 1 harvestable redear sunfish, and 12 harvestable largemouth bass per hectare in Bull Pond (Table 7).

No previous fisheries studies have been done on Bull Pond, but the lake is private and located on undeveloped land. The owner (Mr. Jack Williams of Gainesville, Florida) and his land caretaker have observed no major change in the fish population over the last several years.

Mill Dam

Location and Morphology

Mill Dam is located in Marion County, Florida (Latitude 29.10 N; Longitude 81.50 W). The lake lies in the Lynne Karst division of the Central Lake District (Brooks 1981). The geology is dominated by deeply weathered clayey sand and granular sand of the Hawthorne Formation. Mill Dam was sampled from 1989 to 1990 and had a surface area, shoreline length, and mean depth of 85 ha, 3.56 km, and 5.7 m, respectively (Table 1).

Trophic Status and Water Chemistry

Mill Dam had an average total phosphorus concentration of 11 µg/L and an average total nitrogen concentration of 462 µg/L. Total chlorophyll *a* concentrations averaged 4 µg/L and the water clarity as measured by use of a Secchi disc averaged 2.7 m (Table 2). The lake had an average pH of 6.6 and an average total alkalinity of 3.9 mg/L as $CaCO_3$. The average specific conductance was 45 µS/cm @ 25 C and the average water color was 7 Pt-Co units. The adjusted chlorophyll *a* value for Mill Dam was 5.8 µg/L. Using this value and the classification system of Forsberg and Ryding (1980), Mill Dam was classified as a mesotrophic lake during this study. **(Text continued on page 411)**

Table 191. Blocknet-rotenone estimates of total and harvestable fish stock (number/hectare) and standing crop (kg/hectare) for Bull Pond. Mean values for littoral and open-water nets are listed by species with the corresponding standard error of the mean.

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Littoral nets (n=2) for total fish				
Florida gar	31	31	4.5	4.52
Bowfin	12	12	12.1	12.07
Redfin pickerel	68	68	4.4	4.42
Golden shiner	6	6	0.1	0.08
Taillight shiner	2970	2686	1.8	1.72
Lake chubsucker	587	587	4.1	4.10
Yellow bullhead	31	19	0.8	0.21
Tadpole madtom	105	93	0.4	0.40
Golden topminnow	803	803	0.9	0.91
Lined topminnow	1130	1093	0.8	0.77
Mosquitofish	2896	2871	0.9	0.89
Least killifish	6	6	0.0	0.00
Brook silverside	142	142	0.1	0.13
Everglades pygmy sunfish	377	377	0.0	0.05
Bluespotted sunfish	692	605	0.3	0.23
Warmouth	6089	5236	14.6	11.76
Bluegill	10572	9942	55.5	49.29
Dollar sunfish	142	142	0.3	0.31
Redear sunfish	56	6	4.8	0.44
Largemouth bass	1538	1426	4.6	1.10
Black crappie	31	19	6.1	6.07
Swamp darter	161	161	0.1	0.06
Total	28442		117.3	

Table 191. (Continued)

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Open-water nets (n=2) for total fish				
Florida gar	0	0	0.0	0.00
Bowfin	0	0	0.0	0.00
Redfin pickerel	0	0	0.0	0.00
Golden shiner	0	0	0.0	0.00
Taillight shiner	0	0	0.0	0.00
Lake chubsucker	6	6	3.0	3.01
Yellow bullhead	0	0	0.0	0.00
Tadpole madtom	0	0	0.0	0.00
Golden topminnow	0	0	0.0	0.00
Lined topminnow	0	0	0.0	0.00
Mosquitofish	0	0	0.0	0.00
Least killifish	0	0	0.0	0.00
Brook silverside	0	0	0.0	0.00
Everglades pygmy sunfish	0	0	0.0	0.00
Bluespotted sunfish	0	0	0.0	0.00
Warmouth	0	0	0.0	0.00
Bluegill	506	124	33.1	7.07
Dollar sunfish	0	0	0.0	0.00
Redear sunfish	0	0	0.0	0.00
Largemouth bass	19	6	3.7	1.27
Black crappie	12	12	0.3	0.25
Swamp darter	0	0	0.0	0.00
Total	543		40.0	

Table 191. (Concluded)

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Littoral nets (n=2) for harvestable fish				
Yellow bullhead	0	0.0	0.0	0.00
Warmouth	0	0.0	0.0	0.00
Bluegill	266	216.1	41.3	36.88
Dollar sunfish	0	0.0	0.0	0.00
Redear sunfish	37	12.3	4.7	0.44
Largemouth bass	6	6.2	1.0	0.98
Black crappie	25	24.7	6.1	6.07
Total	333		53.1	
Open-water nets (n=2) for harvestable fish				
Yellow bullhead	0	0.0	0.0	0.00
Warmouth	0	0.0	0.0	0.00
Bluegill	253	18.5	24.8	2.40
Dollar sunfish	0	0.0	0.0	0.00
Redear sunfish	0	0.0	0.0	0.00
Largemouth bass	19	6.2	3.7	1.27
Black crappie	0	0.0	0.0	0.00
Total	272		28.5	

Table 192. Experimental gillnet (five, ten meter long sections of 1.9, 2.5, 3.8, 5.1, and 6.4 cm bar mesh, which were 2.4 meter deep) catch per unit effort estimates of total and harvestable fish number (number/net/24 hr) and weight (kg/net/24 hr) for Bull Pond. Mean values for experimental gillnets are listed by species with the corresponding standard error of the mean.

Common Name	Fish number (number/net/24 hr)	Standard Error	Fish weight (kg/net/24 hr)	Standard Error
Gillnets (n=3) for total fish				
Florida gar	7.3	2.19	4.6	1.82
Golden shiner	1.0	0.58	0.1	0.09
Lake chubsucker	4.0	2.52	2.1	1.26
Yellow bullhead	1.0	0.58	0.4	0.22
Warmouth	0.3	0.33	0.0	0.01
Bluegill	1.7	0.88	0.2	0.13
Black crappie	1.7	0.33	0.2	0.04
Total	17.00		7.62	
Gillnets (n=3) for harvestable fish				
Yellow bullhead	1.0	0.58	0.4	0.22
Warmouth	0.0	0.00	0.0	0.00
Bluegill	1.3	0.88	0.2	0.13
Black crappie	0.7	0.33	0.1	0.06
Total	3.0		0.8	

Table 193. Electrofishing catch per unit effort estimates of total and harvestable fish number (number/hr) and weight (kg/hr) for Bull Pond. Mean values are listed by species with the corresponding standard error of the mean.

Common Name	Number (number/hr)	Standard Error	Weight (kg/hr)	Standard Error
Electrofishing runs (n=4) for total fish				
Florida gar	36.0	20.05	63.0	3.38
Bowfin	1.5	1.50	23.9	2.39
Taillight shiner	3.0	3.00	0.0	0.00
Lake chubsucker	30.0	18.17	5.4	0.15
Yellow bullhead	1.5	1.50	7.2	0.72
Lined topminnow	1.5	1.50	0.0	0.00
Mosquitofish	3.0	1.73	0.0	0.00
Bluespotted sunfish	3.0	3.00	0.0	0.00
Warmouth	3.0	3.00	0.0	0.00
Bluegill	27.0	13.53	2.2	0.04
Redear sunfish	1.5	1.50	1.0	0.10
Largemouth bass	42.0	4.90	111.9	1.67
Total	153.0		214.7	
Electrofishing runs (n=4) for harvestable fish				
Yellow bullhead	1.5	1.50	0.7	0.72
Warmouth	0.0	0.00	0.0	0.00
Bluegill	1.5	1.50	0.10	0.08
Redear sunfish	1.5	1.50	0.1	0.10
Largemouth bass	27.0	7.14	9.8	1.78
Total	31.5		10.7	

Aquatic Plants

Mill Dam had a moderate abundance of aquatic macrophytes with a percent area coverage (PAC) and percent volume infested (PVI) with aquatic macrophytes of 33%, and 9.1%, respectively (Table 3). The average above-ground biomass of emergent, floating-leaved and submersed vegetation was 2.1, 1.2 and 0.7 kg wet wt/m^2, respectively (Table 3). The average epiphytic algal concentration associated with the aquatic macrophytes was

14.2 mg chlorophyll *a*/cm^2 of host plant and 28 mg chlorophyll *a*/kg wet wt of host plant (Table 3). Twenty-four species of aquatic macrophytes were collected from Mill Dam. The most commonly encountered plant species were *Panicum hemitomon, Nymphaea odorata,* and *Bacopa caroliniana,* which occurred in 100%, 90% and 70% of the transects, respectively (Table 194).

The plant community in Mill Dam has been monitored by the Florida Department of Natural Resources from 1982 to present. The major plants during that time were *Hydrilla verticillata, Panicum hemitomon* and *Utricularia floridana*. At the highest coverage, these plants only covered about 15% of Mill Dam's surface area. Thus, the fish population in Mill Dam can be considered the product of a mesotrophic lake with moderate to low levels of aquatic macrophytes.

Invertebrates

The average number and biomass of epiphytic macroinvertebrates in Mill Dam was 77 individuals/kg wet wt of host plant and 0.11 g wet wt/kg wet wt of host plant (Table 5). Average number and biomass of benthic macroinvertebrates in Mill Dam, as estimated with a ponar dredge, was 827 individuals/m^2 and 2.57 g wet wt/m^2 (Table 5). The zooplankton population in Mill Dam was dominated by nauplii and rotifers with 67,800 and 49,900 individuals/m^3, respectively (Table 5).

Fish

Twenty-nine species of fish were collected in Mill Dam (Table 195, 196, and 197). The most abundant species collected with rotenone sampling were bluespotted sunfish and warmouth. These species had average standing stocks in littoral blocknets of 1,300 and 1,000 fish/ha, respectively (Table 195). The most abundant open-water species collected in the experimental gillnets were Florida gar and gizzard shad with 4.3 and 3.3 fish/net/24 hr, respectively (Table 196). The most abundant species collected using electrofishing were bluegill and lake chubsucker with catch per unit efforts of 28 and 18 fish per hour, respectively (Table 197). Average first year growth of bluegill, redear sunfish, and largemouth bass was 40, 57, and 144 mm TL, respectively (Table 6). Mark-recapture estimates indicated that there were 2 harvestable bluegill and 8 harvestable largemouth bass per hectare in Mill Dam (Table 7).

Table 194. Occurrence of plant species in ten evenly spaced transects around Mill Dam.

Common name	Scientific name	Percent of Transects
slender spikerush	*Eleocharis baldwinii*	60
banana-lily	*Nymphoides aquatica*	30
water-shield	*Brasenia schreberi*	10
spatterdock	*Nuphar luteum*	30
fragrant water-lily	*Nymphaea odorata*	90
red ludwigia	*Ludwigia repens*	10
pickerelweed	*Pontederia cordata*	20
lemon bacopa	*Bacopa caroliniana*	70
cat-tail	*Typha* spp.	10
water-pennywort	*Hydrocotyle umbellata*	20
strap-laef sag	*Sagittaria kurziana*	10
variable-leaf milfoil	*Myriophyllum heterophyllum*	30
hydrilla	*Hydrilla verticillata*	10
purple bladderwort	*Utricularia purpurea*	70
bog-moss	*Mayaca fluviatilis*	40
purple fanwort	*Cabomba pulcherrima*	20
buttonbush	*Cephalanthus occidentalis*	20
sawgrass	*Cladium jamaicense*	50
maidencane	*Panicum hemitomon*	100
	Fuirena sciropoidea	40
	Utricularia floridana	60
St. John's wort	*Hypericum* spp.	10
yellow-eyed grass	*Xyris* spp.	20
	Utricularia foliosa	40

The fish population in Mill Dam was sampled for species composition with electrofishing in 1984 and 1986 by US Forests Service (unpublished data). A total of 11 species of fish were collected and the dominant species by weight were largemouth bass, lake chubsucker and Florida gar, which is identical to the electrofishing samples reported in this study (Table 197). These data suggest that the fish population in Mill Dam has remained stable for the last several years. **(Text continued on page 418)**

Table 195. Blocknet-rotenone estimates of total and harvestable fish stock (number/hectare) and standing crop (kg/hectare) for Mill Dam. Mean values for littoral and open-water nets are listed by species with the corresponding standard error of the mean.

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Littoral nets (n=3) for total fish				
Florida gar	4	4	0.2	0.21
Bowfin	4	4	2.3	2.26
Redfin pickerel	91	50	1.0	0.53
Chain pickerel	8	8	2.2	2.18
Golden shiner	17	16	0.1	0.12
Taillight shiner	4	4	2.0	2.01
Lake chubsucker	62	50	2.0	1.57
Yellow bullhead	17	16	0.3	0.26
Tadpole madtom	226	132	1.3	0.99
Golden topminnow	41	22	0.0	0.03
Lined topminnow	152	54	0.2	0.09
Bluefin killifish	95	47	0.0	0.03
Mosquitofish	29	23	0.0	0.01
Least killifish	4	4	0.0	0.00
Everglades pygmy sunfish	21	21	0.0	0.00
Blackbanded sunfish	296	206	0.3	0.25
Bluespotted sunfish	1346	647	1.2	0.68
Warmouth	1021	467	14.8	6.09
Bluegill	580	483	2.4	2.31
Dollar sunfish	716	271	1.3	0.54
Redear sunfish	78	43	1.1	0.81
Spotted sunfish	29	11	0.2	0.11
Largemouth bass	21	15	1.2	1.21
Black crappie	29	15	2.2	1.17
Swamp darter	0	0	0.0	0.00
Total	4890		36.3	

Table 195. (Continued)

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Open-water nets (n=3) for total fish				
Florida gar	0	0	0.0	0.00
Bowfin	0	0	0.0	0.00
Redfin pickerel	4	4	0.0	0.04
Chain pickerel	8	4	2.2	1.51
Golden shiner	0	0	0.0	0.00
Taillight shiner	0	0	0.0	0.00
Lake chubsucker	12	12	1.1	1.05
Yellow bullhead	0	0	0.0	0.00
Tadpole madtom	0	0	0.0	0.00
Golden topminnow	0	0	0.0	0.00
Lined topminnow	4	4	0.0	0.01
Bluefin killifish	214	214	0.0	0.05
Mosquitofish	0	0	0.0	0.00
Least killifish	0	0	0.0	0.00
Everglades pygmy sunfish	21	21	0.0	0.02
Blackbanded sunfish	4	4	0.0	0.00
Bluespotted sunfish	301	288	0.1	0.05
Warmouth	1252	1239	0.4	0.36
Bluegill	1478	1043	8.7	3.38
Dollar sunfish	49	49	0.0	0.05
Redear sunfish	86	86	2.1	2.06
Spotted sunfish	0	0	0.0	0.00
Largemouth bass	235	177	28.5	23.84
Black crappie	8	8	1.3	1.30
Swamp darter	4	4	0.0	0.00
Total	3680		44.4	

Table 195. (Concluded)

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Littoral nets (n=3) for harvestable fish				
Chain pickerel	4	4.1	1.7	1.70
Yellow bullhead	0	0.0	0.0	0.00
Warmouth	45	21.8	4.4	2.06
Bluegill	12	12.4	1.0	0.99
Dollar sunfish	0	0.0	0.0	0.00
Redear sunfish	8	8.2	0.6	0.64
Spotted sunfish	0	0.0	0.0	0.00
Largemouth bass	4	4.1	0.8	0.82
Black crappie	8	4.1	1.1	0.54
Total	82		9.6	
Open-water nets (n=3) for harvestable fish				
Chain pickerel	4	4.1	1.7	1.70
Yellow bullhead	0	0.0	0.0	0.00
Warmouth	0	0.0	0.0	0.00
Bluegill	12	7.1	1.8	0.92
Dollar sunfish	0	0.0	0.0	0.00
Redear sunfish	12	12.4	1.8	1.79
Spotted sunfish	0	0.0	0.0	0.00
Largemouth bass	33	21.8	24.3	22.41
Black crappie	8	8.2	1.3	1.30
Total	70		30.9	

Table 196. Experimental gillnet (five 10-meter long sections of 1.9, 2.5, 3.8, 5.1, and 6.4 cm bar mesh, which were 2.4 meter deep) catch per unit effort estimates of total and harvestable fish number (number/net/24 hr) and weight (kg/net/24 hr) for Mill Dam. Mean values for experimental gillnets are listed by species with the corresponding standard error of the mean.

Common Name	Fish number (number/net/24 hr)	Standard Error	Fish weight (kg/net/24 hr)	Standard Error
Gillnets (n=3) for total fish				
Florida gar	4.3	2.03	0.5	0.21
Bowfin	0.3	0.33	0.4	0.45
Gizzard shad	3.3	1.45	1.3	0.60
Chain pickerel	1.0	0.58	1.0	0.52
Golden shiner	0.7	0.67	0.1	0.12
Lake chubsucker	1.0	1.00	0.1	0.11
Yellow bullhead	0.3	0.33	0.1	0.05
Brown bullhead	0.3	0.33	0.1	0.08
Warmouth	0.7	0.33	0.1	0.03
Bluegill	0.3	0.33	0.0	0.01
Largemouth bass	1.3	0.67	0.2	0.16
Black crappie	1.0	1.00	0.1	0.13
Total	14.7		4.1	
Gillnets (n=3) for harvestable fish				
Chain pickerel	0.7	0.33	1.0	0.49
Yellow bullhead	0.3	0.33	0.1	0.05
Brown bullhead	0.3	0.33	0.1	0.08
Warmouth	0.3	0.33	0.0	0.04
Bluegill	0.0	0.00	0.0	0.00
Largemouth bass	0.7	0.67	0.2	0.18
Black crappie	0.3	0.33	0.1	0.11
Total	2.7		1.4	

Table 197. Electrofishing catch per unit effort estimates of total and harvestable fish number (number/hr) and weight (kg/hr) for Mill Dam. Mean values are listed by species with the corresponding standard error of the mean.

Common Name	Number (number/hr)	Standard Error	Weight (kg/hr)	Standard Error
Electrofishing runs (n=6) for total fish				
Florida gar	16.0	3.34	15.1	0.37
Bowfin	2.0	1.29	10.5	0.67
Chain pickerel	1.0	1.00	4.2	0.42
Golden shiner	3.0	2.04	0.2	0.01
Lake chubsucker	18.0	3.46	31.7	0.91
Yellow bullhead	1.0	1.00	3.6	0.36
Brook silverside	2.0	2.00	0.0	0.00
Tidewater silverside	3.0	2.04	0.0	0.00
Bluegill	28.0	8.00	11.4	0.56
Redear sunfish	2.0	2.00	0.4	0.04
Largemouth bass	12.0	3.79	72.5	3.77
Total	88.0		149.6	
Electrofishing runs (n=6) for harvestable fish				
Chain pickerel	1.0	1.00	0.4	0.42
Yellow bullhead	1.0	1.00	0.4	0.36
Bluegill	6.0	3.79	0.7	0.47
Redear sunfish	0.0	0.00	0.0	0.00
Largemouth bass	9.0	3.38	7.1	3.76
Total	17.0		8.6	

West Moody

Location and Morphology

West Moody is located in Pasco County, Florida (Latitude 28.24 N; Longitude 82.18 W). The lake lies in the Dade City Hills division of the Ocala Uplift District (Brooks 1981).

The geology is dominated by sand, silty sand and phosphatic clays of the Hawthorne Formation. West Moody was sampled from 1989 to 1990 and had a surface area, shoreline length, and mean depth of 39 ha, 2.50 km and 3.5 m, respectively (Table 1).

Trophic Status and Water Chemistry

West Moody had an average total phosphorus concentration of 14 µg/L and an average total nitrogen concentration of 584 µg/L. Total chlorophyll *a* concentrations averaged 2 µg/L and the water clarity as measured by use of a Secchi disc averaged 2.8 m (Table 2). The lake had an average pH of 6.6 and an average total alkalinity of 31 mg/L as $CaCO_3$. The average specific conductance was 127 µS/cm @ 25 C and the average water color was 20 Pt-Co units. The adjusted chlorophyll *a* value for West Moody was 18.5 µg/L. Using this value and the classification system of Forsberg and Ryding (1980), West Moody was classified as an eutrophic lake.

Aquatic Plants

West Moody had a high abundance of aquatic macrophytes with a percent area coverage (PAC) and percent volume infested (PVI) with aquatic macrophytes of 100% and 89%, respectively (Table 3). The average above-ground biomass of emergent, floating-leaved and submersed vegetation was 1.3, 2.1 and 3.2 kg wet wt/m^2, respectively (Table 3). The average epiphytic algal concentration associated with the aquatic macrophytes was 14.4 mg chlorophyll *a*/cm^2 of host plant and 46.6 mg chlorophyll *a*/kg wet wt of host plant (Table 3). Fourteen species of aquatic macrophytes were collected in West Moody. The most commonly encountered plant species were *Hydrilla verticillata, Eichhornia crassipes,* and *Salix* spp., which occurred in 100%, 90% and 60% of the transects, respectively (Table 198).

No previous plant studies have been conducted on West Moody Lake. The residents living on the lake, however, agree that the lake has been covered with hydrilla for several years prior to this study. Thus, the fish population in West Moody can be considered the product of an eutrophic lake with high levels of aquatic vegetation.

Table 198. Occurrence of plant species in ten evenly-spaced transects around West Moody Lake.

Common name	Scientific name	Percent of Transects
floating water-hyacinth	*Eichhornia crassipes*	90
common salvinia	*Salvinia rotundifolia*	30
duck-potato	*Sagittaria lancifolia*	10
parrot's-feather	*Myriophyllum aquaticum*	10
frog's-bit	*Limnobium spongia*	10
cat-tail	*Typha* spp.	30
water-pennywort	*Hydrocotyle umbellata*	10
hydrilla	*Hydrilla verticillata*	100
elephant-ear	*Colocasia esculenta*	10
wax myrtle	*Myrica ceriferia*	10
water primrose	*Ludwigia octovalis*	20
willow	*Salix* spp.	60
giant bulrush	*Scirpus californicus*	10
	Scirpus cubensis	40

Invertebrates

The average number and biomass of epiphytic macroinvertebrates in West Moody was 147 individuals/kg wet wt of host plant and 0.24 g wet wt/kg wet wt of host plant (Table 5). Average number and biomass of benthic macroinvertebrates in West Moody, as estimated with a ponar dredge, was 80 individuals/m^2 and 0.15 g wet wt/m^2 (Table 5). The zooplankton population in West Moody was dominated by cladocerans and copepods with 234,000 and 177,000 individuals/m^3, respectively (Table 5).

Fish

Eighteen species of fish were collected in West Moody (Table 199, 200 and 201). The most abundant species collected with rotenone sampling were bluespotted sunfish and warmouth. These species had average standing stocks in littoral blocknets of 27,500 and 6,700 fish/ha, respectively (Table 199). The most abundant open-water species collected in the experimental gillnets were largemouth bass and Florida gar with 7 and 5.7 fish/net/24 hr, respectively (Table 200). The most abundant species collected using electrofishing were the mosquitofish, and largemouth bass with catch **(Text continued on page 424)**

Table 199. Blocknet-rotenone estimates of total and harvestable fish stock (number/hectare) and standing crop (kg/hectare) for West Moody. Mean values for littoral and open-water nets are listed by species with the corresponding standard error of the mean.

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Littoral nets (n=2) for total fish				
Florida gar	0	0	0.0	0.00
Bowfin	12	0	20.0	0.33
Golden shiner	346	0	2.8	0.23
Lake chubsucker	210	185	7.4	2.47
Golden topminnow	2260	457	3.1	0.93
Seminole killifish	562	562	1.5	1.51
Flagfish	1686	1389	1.7	1.44
Mosquitofish	5224	3297	1.8	0.85
Least killifish	80	80	0.0	0.01
Sailfin molly	710	500	1.1	0.80
Bluespotted sunfish	27503	4236	18.5	2.61
Warmouth	6675	2044	73.5	16.16
Bluegill	3915	630	31.9	1.09
Redear sunfish	2803	74	26.0	8.75
Largemouth bass	3069	1501	26.6	2.85
Black crappie	68	31	3.9	0.81
Total	55124		219.9	
Littoral nets (n=2) for harvestable fish				
Warmouth	68	43.2	7.3	3.73
Bluegill	37	12.3	3.3	1.12
Redear sunfish	37	24.7	3.4	2.24
Largemouth bass	49	12.3	13.2	2.63
Black crappie	12	12.3	2.0	1.95
Total	204		29.2	

Table 199. (Concluded)

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Open-water nets (n=2) for total fish				
Florida gar	6	6	3.1	3.08
Bowfin	6	6	4.9	4.92
Golden shiner	284	198	5.8	3.08
Lake chubsucker	56	6	8.9	3.41
Golden topminnow	198	74	0.2	0.17
Seminole killifish	0	0	0.0	0.00
Flagfish	0	0	0.0	0.00
Mosquitofish	513	513	0.2	0.16
Least killifish	0	0	0.0	0.00
Sailfin molly	0	0	0.0	0.00
Bluespotted sunfish	15901	10195	11.3	7.40
Warmouth	4625	2587	33.1	21.80
Bluegill	6688	1031	51.5	11.61
Redear sunfish	2445	1013	12.3	4.99
Largemouth bass	2254	488	15.4	0.94
Black crappie	68	31	9.8	5.85
Total	33042		156.4	
Open-water nets (n=2) for harvestable fish				
Warmouth	19	6.2	1.9	0.61
Bluegill	19	6.2	2.2	0.18
Redear sunfish	6	6.2	1.1	1.14
Largemouth bass	25	0.0	9.4	0.91
Black crappie	43	30.9	8.4	5.61
Total	111		22.9	

Table 200. Experimental gillnet (five 10-meter long sections of 1.9, 2.5, 3.8, 5.1, and 6.4 cm bar mesh, which were 2.4 meter deep) catch per unit effort estimates of total and harvestable fish number (number/net/24 hr) and weight (kg/net/24 hr) for West Moody. Mean values for experimental gillnets are listed by species with the corresponding standard error of the mean.

Common Name	Fish number (number/net/24 hr)	Standard Error	Fish weight (kg/net/24 hr)	Standard Error
Gillnets (n=3) for total fish				
Florida gar	5.7	0.67	4.4	1.28
Bowfin	1.3	0.88	1.7	0.86
Golden shiner	1.7	0.88	0.1	0.05
Lake chubsucker	0.7	0.33	0.5	0.29
Brown bullhead	0.3	0.33	0.2	0.24
Warmouth	1.7	0.33	0.1	0.03
Bluegill	1.0	0.58	0.2	0.18
Largemouth bass	7.0	1.73	3.0	0.55
Black crappie	0.3	0.33	0.0	0.02
Total	19.7		10.2	
Gillnets (n=3) for harvestable fish				
Brown bullhead	0.3	0.33	0.2	0.24
Warmouth	0.7	0.33	0.1	0.05
Bluegill	0.7	0.67	0.2	0.18
Largemouth bass	2.7	0.33	2.6	0.45
Black crappie	0.0	0.00	0.0	0.00
Total	4.3		3.1	

Table 201. Electrofishing catch per unit effort estimates of total and harvestable fish number (number/hr) and weight (kg/hr) for West Moody. Mean values are listed by species with the corresponding standard error of the mean.

Common Name	Number (number/hr)	Standard Error	Weight (kg/hr)	Standard Error
Electrofishing runs (n=4) for total fish				
Florida gar	12.0	4.24	71.5	3.11
Golden shiner	33.0	15.59	3.9	0.21
Lake chubsucker	25.5	6.65	50.8	2.31
Golden topminnow	15.0	3.00	0.2	0.00
Flagfish	6.0	6.00	0.2	0.02
Mosquitofish	135.0	80.44	0.5	0.03
Sailfin molly	3.0	1.73	0.10	0.01
Bluespotted sunfish	9.0	5.74	0.10	0.01
Warmouth	30.0	4.24	4.3	0.10
Bluegill	90.0	22.32	7.9	0.28
Redear sunfish	45.0	23.17	3.0	0.09
Largemouth bass	106.5	7.50	49.9	1.69
Black crappie	3.0	3.00	6.2	0.62
Swamp darter	1.5	1.50	0.0	0.00
Total	514.5		198.3	
Electrofishing runs (n=4) for harvestable fish				
Warmouth	0.0	0.00	0.0	0.00
Bluegill	0.0	0.00	0.0	0.00
Redear sunfish	0.0	0.00	0.0	0.00
Largemouth bass	6.0	2.45	2.5	1.40
Black crappie	3.0	3.00	0.6	0.62
Total	9.0		3.2	

per unit efforts of 135 and 107 fish per hour, respectively (Table 201). Average first year growth of bluegill, redear sunfish, and largemouth bass was 69, 70, and 148 mm TL, respectively (Table 6). Mark-recapture estimates indicated that there were 28 harvestable largemouth bass per hectare in West Moody (Table 7).

No previous fisheries studies have been conducted on West Moody. The resident living on the lake, however, have noticed no major change in the fish population over the last several years.

Grasshopper

Location and Morphology

Grasshopper is located in Lake County, Florida (Latitude 29.08 N; Longitude 81.37 W). The lake lies in the Ocala Scrub division of the Ocala Uplift District (Brooks 1981). The geology is dominated by sand dunes of well sorted fine sand. Grasshopper was sampled from 1989 to 1990 and had a surface area, shoreline length, and mean depth of 59 ha, 5.07 km, and 2.7 m, respectively (Table 1).

Trophic Status and Water Chemistry

Grasshopper had an average total phosphorus concentration of 6 µg/L and an average total nitrogen concentration of 259 µg/L. Total chlorophyll *a* concentrations averaged 1 µg/L and the water clarity as measured by use of a Secchi disc averaged 3.7 m (Table 2). The lake had an average pH of 4.5 and an average total alkalinity of 0.1 mg/L as $CaCO_3$. The average specific conductance was 61 µS/cm @ 25 C and the average water color was 0 Pt-Co units. The adjusted chlorophyll *a* value for Grasshopper was 2 µg/L. Using this value and the classification system of Forsberg and Ryding (1980), Grasshopper was classified as an oligotrophic lake.

Aquatic Plants

Grasshopper had a moderate abundance of aquatic macrophytes with a percent area coverage (PAC) and percent volume infested (PVI) with aquatic macrophytes of 80% and 17%, respectively (Table 3). The average above-ground biomass of emergent, floating-leaved and submersed vegetation was 0.3, 0.2, and 0.3 kg wet wt/m^2, respectively (Table 3). The average epiphytic algal concentration associated with the aquatic macrophytes was 29.2 mg chlorophyll *a*/cm^2 of host plant and 18.6 mg chlorophyll *a*/kg wet wt of host plant (Table 3). Fourteen species of aquatic macrophytes were collected from Grasshopper. The most commonly encountered plant species were *Panicum hemitomon, Cephalanthus occidentalis,* and *Eriocaulon* spp., which occurred in 90%, 70% and 70% of the transects, respectively (Table 202).

Table 202. Occurrence of plant species in ten evenly-spaced transects around Grasshopper Lake.

Common name	Scientific name	Percent of Transects
slender spikerush	*Eleocharis baldwinii*	10
banana-lily	*Nymphoides aquatica*	30
spatterdock	*Nuphar luteum*	40
fragrant water-lily	*Nymphaea odorata*	30
pickerelweed	*Pontederia cordata*	20
purple bladderwort	*Utricularia purpurea*	40
buttonbush	*Cephalanthus occidentalis*	70
maidencane	*Panicum hemitomon*	90
	Fuirena sciropoidea	50
	Leersia hexandra	50
pipewort	*Eriocaulon* spp.	70
St. John's wort	*Hypericum* spp.	50
	Rhynchyospora tracyi	30
	Rhynchospora inundata	20

The plant community of Grasshopper has been monitored by the Florida Department of Natural Resources from 1984 to present. The major aquatic plants during that time were *Panicum hemitomon* and *Utricularia* spp., which covered a maximum of 32% of the lake's surface area. Thus, the fish population in Grasshopper can be considered the product of an oligotrophic lake with low to moderate level of vegetation.

Invertebrates

The average number and biomass of epiphytic macroinvertebrates in Grasshopper was 78 individuals/kg wet wt of host plant and 0.06 g wet wt/kg wet wt of host plant (Table 5). Average number and biomass of benthic macroinvertebrates in Grasshopper, as estimated with a ponar dredge, was 144 individuals/m^2 and 1.15 g wet wt/m^2 (Table 5). The zooplankton population in Grasshopper was dominated by nauplii and rotifers with 104,000 and 35,100 individuals/m^3, respectively (Table 5).

Fish

Twenty-one species of fish were collected in Grasshopper (Table 203, 204 and 205). The most abundant species collected with rotenone sampling were warmouth and bluespotted sunfish. These species had average standing stocks in littoral blocknets of 2,500 and 1,900 fish/ha, respectively (Table 203). The most abundant open-water species collected in the experimental gillnets were largemouth bass and Florida gar with 4.7 and 2.3 fish/net/24 hr, respectively (Table 204). The most abundant species collected using electrofishing were lake chubsucker and largemouth bass with catch per unit efforts of 49.2, and 22.8 fish per hour, respectively (Table 205). Average first year growth of bluegill, redear sunfish and largemouth bass was 49, 66, and 142 mm TL, respectively (Table 6). Mark-recapture estimates indicated that there were 13 harvestable largemouth bass per hectare in Grasshopper (Table 7).

The fish population in Grasshopper was sampled with one littoral blocknet by the Florida Game and Fresh Water Fish Commission in 1986. The major species collected were lake chubsucker, largemouth bass and bluegill and the total standing crop was 85 kg/ha. The major species were the same as those reported for the littoral nets during this study, but the standing crop was less (Table 203). The lower standing crop may result because only one net was used. These data, however, suggest that no major change in the fish population of Grasshopper has occurred in recent history.

Mountain

Location and Morphology

Mountain is located in Hernando County, Florida (Latitude 28.28 N; Longitude 82.18 W). The lake lies in the Dade City Hills division of the Ocala Uplift District (Brooks 1981). The geology is dominated by sand, silty sand and phosphatic clays of the Hawthorne Formation. Mountain was sampled from 1989 to 1990 and had a surface area, shoreline length, and mean depth of 51 ha, 2.25 km and 1.6 m, respectively (Table 1).

Trophic Status and Water Chemistry

Mountain had an average total phosphorus concentration of 37 µg/L and an average total nitrogen concentration of 813 µg/L. Total chlorophyll *a* concentrations averaged 10 µg/L and the water clarity as measured by use of a **(Text continued on page 432)**

Table 203. Blocknet-rotenone estimates of total and harvestable fish stock (number/hectare) and standing crop (kg/hectare) for Grasshopper. Mean values for littoral and open-water nets are listed by species with the corresponding standard error of the mean.

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Littoral nets (n=3) for total fish				
Florida gar	8	4	1.8	0.95
Redfin pickerel	17	8	0.2	0.08
Chain pickerel	45	21	6.8	2.46
Lake chubsucker	1000	43	46.1	10.22
Yellow bullhead	45	11	5.8	3.57
Brown bullhead	173	99	19.5	14.44
Tadpole madtom	45	23	0.1	0.06
Golden topminnow	82	30	0.1	0.04
Lined topminnow	103	91	0.1	0.10
Pygmy killifish	8	4	0.0	0.00
Brook silverside	78	39	0.1	0.04
Everglades pygmy sunfish	268	83	0.0	0.01
Bluespotted sunfish	1894	604	1.5	0.50
Warmouth	2478	574	22.0	2.71
Bluegill	1811	479	25.6	11.46
Dollar sunfish	264	126	0.5	0.24
Redear sunfish	124	89	2.2	1.31
Largemouth bass	140	54	26.8	19.36
Black crappie	17	16	2.2	2.20
Swamp darter	4	4	0.0	0.00
Total	8604		161.4	

Table 203. (Continued)

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Open-water nets (n=3) for total fish				
Florida gar	0	0	0.0	0.00
Redfin pickerel	0	0	0.0	0.00
Chain pickerel	0	0	0.0	0.00
Lake chubsucker	66	41	3.6	3.06
Yellow bullhead	0	0	0.0	0.00
Brown bullhead	4	4	0.0	0.04
Tadpole madtom	0	0	0.0	0.00
Golden topminnow	4	4	0.0	0.01
Lined topminnow	0	0	0.0	0.00
Pygmy killifish	0	0	0.0	0.00
Brook silverside	897	528	0.8	0.56
Everglades pygmy sunfish	4	4	0.0	0.00
Bluespotted sunfish	152	102	0.1	0.07
Warmouth	132	61	0.9	0.60
Bluegill	156	50	5.1	2.58
Dollar sunfish	17	16	0.0	0.02
Redear sunfish	29	29	5.6	5.56
Largemouth bass	37	7	4.5	2.73
Black crappie	0	0	0.0	0.00
Swamp darter	0	0	0.0	0.00
Total	1498		20.8	

Table 203. (Concluded)

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Littoral nets (n=3) for harvestable fish				
Chain pickerel	12	7.1	4.1	2.44
Yellow bullhead	16	10.9	4.8	3.97
Brown bullhead	62	43.4	14.7	11.36
Warmouth	8	8.2	0.7	0.73
Bluegill	91	46.4	12.9	7.79
Dollar sunfish	0	0.0	0.0	0.00
Redear sunfish	8	4.1	1.4	0.69
Largemouth bass	49	25.7	24.4	18.24
Black crappie	16	16.5	2.2	2.20
Total	263		65.2	
Open-water nets (n=3) for harvestable fish				
Chain pickerel	0	0.0	0.0	0.00
Yellow bullhead	0	0.0	0.0	0.00
Brown bullhead	0	0.0	0.0	0.00
Warmouth	0	0.0	0.0	0.00
Bluegill	33	17.9	4.6	2.72
Dollar sunfish	0	0.0	0.0	0.00
Redear sunfish	25	24.7	5.5	5.50
Largemouth bass	8	4.1	3.7	2.62
Black crappie	0	0.0	0.0	0.00
Total	66		13.9	

Table 204. Experimental gillnet (five 10-meter long sections of 1.9, 2.5, 3.8, 5.1, and 6.4 cm bar mesh, which were 2.4 meter deep) catch per unit effort estimates of total and harvestable fish number (number/net/24 hr) and weight (kg/net/24 hr) for Grasshopper. Mean values for experimental gillnets are listed by species with the corresponding standard error of the mean.

Common Name	Fish number (number/net/24 hr)	Standard Error	Fish weight (kg/net/24 hr)	Standard Error
Gillnets (n=3) for total fish				
Florida gar	2.3	1.45	0.9	0.50
Bowfin	0.3	0.33	0.4	0.43
Chain pickerel	0.7	0.33	0.4	0.29
Lake chubsucker	1.3	0.33	0.5	0.25
Yellow bullhead	2.0	1.00	0.9	0.46
Warmouth	1.0	0.58	0.0	0.02
Bluegill	1.7	0.33	0.1	0.02
Redear sunfish	2.0	1.15	0.4	0.25
Largemouth bass	4.7	2.03	0.6	0.17
Black crappie	0.3	0.33	0.1	0.06
Total	16.33		4.40	
Gillnets (n=3) for harvestable fish				
Chain pickerel	0.7	0.33	0.4	0.29
Yellow bullhead	2.0	1.00	0.9	0.46
Warmouth	0.0	0.00	0.0	0.00
Bluegill	0.3	0.33	0.0	0.04
Redear sunfish	2.0	1.15	0.4	0.25
Largemouth bass	1.3	0.88	0.4	0.23
Black crappie	0.3	0.33	0.1	0.06
Total	6.7		2.3	

Table 205. Electrofishing catch per unit effort estimates of total and harvestable fish number (number/hr) and weight (kg/hr) for Grasshopper. Mean values are listed by species with the corresponding standard error of the mean.

Common Name	Number (number/hr)	Standard Error	Weight (kg/hr)	Standard Error
Electrofishing runs (n=5) for total fish				
Florida gar	9.6	3.60	23.4	1.25
Chain pickerel	2.4	1.47	11.1	0.77
Lake chubsucker	49.2	14.99	161.9	6.81
Yellow bullhead	1.2	1.20	3.9	0.39
Warmouth	1.2	1.20	0.3	0.03
Bluegill	9.6	2.40	2.7	0.12
Largemouth bass	22.8	3.98	149.7	5.67
Total	96.0		353.0	
Electrofishing runs (n=5) for harvestable fish				
Chain pickerel	2.4	1.47	1.1	0.77
Yellow bullhead	1.2	1.20	0.4	0.39
Warmouth	0.0	0.00	0.0	0.00
Bluegill	1.2	1.20	0.1	0.14
Largemouth bass	13.2	2.94	14.0	5.52
Total	18.0		15.6	

Secchi disc averaged 1.7 m (Table 2). The lake had an average pH of 7.3 and an average total alkalinity of 26 mg/L as $CaCO_3$. The average specific conductance was 113 µS/cm @ 25 C and the average water color was 39 Pt-Co units. The adjusted chlorophyll *a* value for Mountain Lake was 21.5 µg/L. Using this value and the classification system of Forsberg and Ryding (1980), Mountain Lake was classified as an eutrophic lake during this study.

Aquatic Plants

Mountain had a moderate abundance of aquatic macrophytes with a percent area coverage (PAC) and percent volume infested (PVI) with aquatic macrophytes of 40% and 21%, respectively (Table 3). The average above-ground biomass of emergent, floating-leaved and submersed vegetation was 1.9, 1.8 and 2.0 kg wet wt/m^2, respectively (Table 3). The average epiphytic algal concentration associated with the aquatic macrophytes was 19.8 mg chlorophyll *a*/cm^2 of host plant and 34 mg chlorophyll *a*/kg wet wt of host plant (Table 3). Fifteen species of aquatic macrophytes were collected from Mountain. The most commonly encountered species were *Eichhornia crassipes, Panicum hemitomon,* and *Hydrilla verticillata,* which occurred in 100%, 100%, and 70% of the transects, respectively (Table 206).

No previous vegetation studies have been conducted on Mountain Lake. However, the residents living on the lake agree that hydrilla has been extremely abundant over the last several years. Thus, the fish population in Mountain Lake can be considered the product of an eutrophic lake with high levels of aquatic vegetation.

Invertebrates

The average number and biomass of epiphytic macroinvertebrates in Mountain Lake was 278 individuals/kg wet wt of host plant and 1.01 g/kg wet wt of host plant (Table 5). Average number and biomass of benthic macroinvertebrates in Mountain Lake, as estimated with a ponar dredge, was 200 individuals/m^2 and 0.22 g/m^2 (Table 5). The zooplankton population in Mountain Lake was dominated by copepods and cladocerans with 47,200 and 39,100 individuals/m^3, respectively (Table 5).

Fish

Fourteen species of fish were collected in Mountain Lake (Table 207, 208 and 209). The most abundant species collected with rotenone sampling were bluegill and golden shiner. These species had average standing stocks in littoral blocknets of 11,700, and 8,300 fish/ha, respectively (Table 207). The most abundant open-water species collected in the experimental gillnets were golden shiner and redear sunfish with 21 and 7.3 fish/net/24 hr, respectively (Table 208). The most abundant species collected using electrofishing were bluegill and largemouth bass with catch per unit efforts of 71 and 35 fish per hour,

Table 206. Occurrence of plant species in ten evenly-spaced transects around Mountain Lake.

Common name	Scientific name	Percent of Transects
floating water-hyacinth	*Eichhornia crassipes*	100
common salvinia	*Salvinia rotundifolia*	50
alligator-weed	*Alternanthera philoxeroides*	50
banana-lily	*Nymphoides aquatica*	10
parrot's-feather	*Myriophyllum aquaticum*	10
smartweed	*Polygonum hydropiperoides*	10
pickerelweed	*Pontederia cordata*	30
cat-tail	*Typha* spp.	40
water-pennywort	*Hydrocotyle umbellata*	50
hydrilla	*Hydrilla verticillata*	70
water primrose	*Ludwigia octovalis*	20
buttonbush	*Cephalanthus occidentalis*	70
willow	*Salix* spp.	60
maidencane	*Panicum hemitomon*	100
	Rhynchyospora tracyi	10

respectively (Table 209). Average first year growth of bluegill, redear sunfish and largemouth bass was 73, 80, and 169 mm TL, respectively (Table 6). Mark-recapture estimates indicated that there were 26 harvestable largemouth bass per hectare (Table 7) in Mountain Lake. No previous fisheries studies were found for Mountain Lake.

Douglas

Location and Morphology

Douglas is located in Lake County, Florida (Latitude 28.33 N; Longitude 81.48 W). The lake lies in the Groveland Karst division of the Central Lakes District (Brooks 1981). The geology is dominated by deeply weathered clayey sand and granular sands of the Hawthorne Formation. Douglas was sampled from 1989 to 1990 and had a surface area, shoreline length, and mean depth of 16 ha, 1.75 km and 1.2 m, respectively (Table 1).

(Text continued on page 438)

Table 207. Blocknet-rotenone estimates of total and harvestable fish stock (number/hectare) and standing crop (kg/hectare) for Mountain. Mean values for littoral and open-water nets are listed by species with the corresponding standard error of the mean.

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Littoral nets (n=2) for total fish				
Bowfin	25	12	26.7	6.40
Golden shiner	8349	1988	12.1	3.64
Lake chubsucker	926	62	8.0	0.76
Brown bullhead	513	216	2.8	0.72
Golden topminnow	4946	1710	6.0	2.26
Flagfish	2130	624	2.6	0.91
Mosquitofish	3582	963	1.8	0.41
Least killifish	667	568	0.1	0.07
Warmouth	5397	173	35.5	8.23
Bluegill	11689	3872	25.0	0.38
Redear sunfish	4644	296	27.7	2.91
Largemouth bass	3606	593	26.3	13.81
Black crappie	3940	1865	10.2	4.66
Swamp darter	185	185	0.1	0.07
Total	50598		184.8	
Littoral nets (n=2) for harvestable fish				
Brown bullhead	0	0.0	0.0	0.00
Warmouth	80	43.2	9.0	3.22
Bluegill	49	24.7	7.4	3.05
Redear sunfish	6	6.2	0.6	0.60
Largemouth bass	43	30.9	12.4	10.18
Black crappie	0	0.0	0.0	0.00
Total	179		29.4	

Table 207. (Concluded)

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Open-water nets (n=2) for total fish				
Bowfin	0	0	0.0	0.00
Golden shiner	12	12	0.0	0.02
Lake chubsucker	0	0	0.0	0.00
Brown bullhead	0	0	0.0	0.00
Golden topminnow	0	0	0.0	0.00
Flagfish	0	0	0.0	0.00
Mosquitofish	6	6	0.0	0.01
Least killifish	0	0	0.0	0.00
Warmouth	12	12	0.0	0.01
Bluegill	926	247	59.1	43.88
Redear sunfish	568	124	31.8	4.63
Largemouth bass	93	56	7.7	2.43
Black crappie	6	6	0.0	0.01
Swamp darter	6	6	0.0	0.00
Total	1630		98.7	
Open-water nets (n=2) for harvestable fish				
Brown bullhead	0	0.0	0.0	0.00
Warmouth	0	0.0	0.0	0.00
Bluegill	494	382.8	56.9	44.04
Redear sunfish	167	43.2	17.1	3.39
Largemouth bass	19	6.2	6.1	3.68
Black crappie	0	0.0	0.0	0.00
Total	679		80.1	

Table 208. Experimental gillnet (five 10-meter long sections of 1.9, 2.5, 3.8, 5.1, and 6.4 cm bar mesh, which were 2.4 meter deep) catch per unit effort estimates of total and harvestable fish number (number/net/24 hr) and weight (kg/net/24 hr) for Mountain Lake. Mean values for experimental gill nets are listed by species with the corresponding standard error of the mean.

Common Name	Fish number (number/net/24 hr)	Standard Error	Fish weight (kg/net/24 hr)	Standard Error
Gillnets (n=3) for total fish				
Bowfin	0.7	0.33	1.2	0.64
Golden shiner	20.7	2.19	1.9	0.29
Lake chubsucker	5.7	4.18	2.9	1.93
Brown bullhead	0.3	0.33	0.2	0.23
Warmouth	3.0	1.15	0.3	0.08
Bluegill	1.7	0.33	0.2	0.13
Redear sunfish	7.3	2.33	0.5	0.18
Largemouth bass	5.7	1.45	1.3	0.46
Black crappie	1.0	1.00	0.1	0.11
Total	46.00		8.71	
Gillnets (n=3) for harvestable fish				
Brown bullhead	0.3	0.33	0.2	0.23
Warmouth	1.7	0.33	0.2	0.05
Bluegill	1.0	0.58	0.2	0.14
Redear sunfish	2.0	0.58	0.3	0.08
Largemouth bass	2.3	0.88	0.9	0.45
Black crappie	1.0	1.00	0.1	0.11
Total	8.3		2.0	

Table 209. Electrofishing catch per unit effort estimates of total and harvestable fish number (number/hr) and weight (kg/hr) for Mountain Lake. Mean values are listed by species with the corresponding standard error of the mean.

Common Name	Number (number/hr)	Standard Error	Weight (kg/hr)	Standard Error
Electrofishing runs (n=4) for total fish				
Bowfin	6.0	2.45	67.2	2.70
Golden shiner	24.0	6.48	11.6	0.68
Lake chubsucker	18.0	6.48	29.5	0.73
Flagfish	3.0	3.00	0.0	0.00
Mosquitofish	6.0	4.24	0.0	0.00
Bluegill	70.5	26.54	23.1	0.84
Redear sunfish	15.0	3.87	7.3	0.60
Largemouth bass	34.5	7.89	80.5	1.84
Black crappie	6.0	3.46	0.10	0.01
Total	183.0		219.4	
Electrofishing runs (n=4) for harvestable fish				
Bluegill	7.5	3.77	1.5	0.95
Redear sunfish	4.5	4.50	0.6	0.58
Largemouth bass	16.5	3.77	6.6	1.86
Black crappie	0.0	0.00	0.0	0.00
Total	28.5		8.7	

Trophic Status and Water Chemistry

Douglas had an average total phosphorus concentration of 11 µg/L and an average total nitrogen concentration of 1122 µg/L. Total chlorophyll *a* concentrations averaged 2 µg/L and the water clarity as measured by use of a Secchi disc averaged 1.5 m (Table 2). The lake had an average pH of 7.2 and an average total alkalinity of 27 mg/L as $CaCO_3$. The average specific conductance was 245 µS/cm @ 25 C and the average water color was 30 Pt-Co units. The adjusted chlorophyll *a* value for Douglas was 12.4 µg/L. Using this value and the classification system of Forsberg and Ryding (1980), Douglas was classified as an eutrophic lake.

Aquatic Plants

Douglas had a high abundance of aquatic macrophytes with a percent area coverage (PAC) and percent volume infested (PVI) with aquatic macrophytes of 97%, and 67%, respectively (Table 3). The average above-ground biomass of emergent, floating-leaved and submersed vegetation was 0.6, 0.4 and 0.8 kg wet wt/m^2, respectively (Table 3). The average epiphytic algal concentration associated with the aquatic macrophytes was 21.4 mg chlorophyll *a*/cm^2 of host plant and 12.2 mg chlorophyll *a*/kg wet wt of host plant (Table 3). Twenty-one species of aquatic macrophytes were collected in Douglas. The most commonly encountered plant species were *Eleocharis baldwinii, Nymphaea odorata,* and *Pontederia cordata,* which occurred in 100%, 100%, and 90% of the transects, respectively (Table 210).

No previous vegetation studies have been conducted on Douglas. The City of Claremont owns most of the land around Douglas, which is use by the city's wastewater treatment plant for land disposal of treated effluent. Personnel from the wastewater treatment plant, who monitor the water quality in Douglas, agree that the vegetation in Douglas has remained stable for the last several years. Thus, the fish population in Douglas can be considered the product of an eutrophic lake with moderate to high levels of aquatic vegetation.

Invertebrates

The average number and biomass of epiphytic macroinvertebrates in Douglas was 34 individuals/kg wet wt of host plant and 0.04 g wet wt/kg wet wt of host plant (Table 5). Average number and biomass of benthic macroinvertebrates in Douglas, as estimated with a ponar dredge, was 213 individuals/m^2 and 0.29 g wet wt/m^2 (Table 5). The zooplankton population in Douglas was dominated by rotifers and nauplii with 440,000 and 156,000 individuals/m^3, respectively (Table 5).

Table 210. Occurrence of plant species in ten evenly-spaced transects around Lake Douglas.

Common name	Scientific name	Percent of Transects
duck-potato	*Sagittaria lancifolia*	30
alligator-weed	*Alternanthera philoxeroides*	10
slender spikerush	*Eleocharis baldwinii*	100
banana-lily	*Nymphoides aquatica*	40
spatterdock	*Nuphar luteum*	40
fragrant water-lily	*Nymphaea odorata*	100
smartweed	*Polygonum hydropiperoides*	30
pickerelweed	*Pontederia cordata*	90
cat-tail	*Typha* spp.	40
water-pennywort	*Hydrocotyle umbellata*	40
purple bladderwort	*Utricularia purpurea*	40
buttonbush	*Cephalanthus occidentalis*	50
sawgrass	*Cladium jamaicense*	50
maidencane	*Panicum hemitomon*	50
cordgrass	*Spartina bakeri*	30
musk-grass	*Chara* spp.	60
	Fuirena sciropoidea	60
	Leersia hexandra	30
pipewort	*Eriocaulon spp.*	50
	Eleocharis cellulosa	20
elderberry	*Sambucus canadensis*	20

Fish

Seventeen species of fish were collected in Douglas (Table 211, 212, and 213). The most abundant species (by numbers) collected with rotenone sampling were dollar sunfish and bluespotted sunfish. These species had average standing stocks in littoral blocknets of 6,600 and 4,200 fish/ha, respectively (Table 211). The most abundant open-water species collected in the experimental gillnets were Florida gar and largemouth bass with 10 and 5.7 fish/net/24 hr, respectively (Table 212). The most abundant species collected using electrofishing were bluegill and lake chubsucker with catch per unit efforts of 150 and 98 fish per hour, respectively (Table 213). Average first year growth of bluegill, redear sunfish, and largemouth bass was 40, 55, and 157 mm TL, respectively (Table 6). No previous fisheries studies have been conducted on Douglas. **(Text continued on page 445)**

Table 211. Blocknet-rotenone estimates of total and harvestable fish stock (number/hectare) and standing crop (kg/hectare) for Douglas. Mean values for littoral and open-water nets are listed by species with the corresponding standard error of the mean.

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Littoral nets (n=2) for total fish				
Florida gar	31	6	12.5	1.53
Golden shiner	31	31	0.8	0.83
Lake chubsucker	86	37	6.0	2.58
Yellow bullhead	62	62	0.2	0.16
Brown bullhead	86	86	0.2	0.23
Golden topminnow	99	25	0.0	0.01
Bluefin killifish	2050	346	1.2	0.71
Tidewater silverside	74	25	0.0	0.01
Bluespotted sunfish	4230	204	2.1	0.06
Warmouth	2013	506	19.2	6.61
Bluegill	3495	1482	11.9	2.60
Dollar sunfish	6613	1661	9.5	3.44
Redear sunfish	408	111	8.6	4.59
Largemouth bass	685	204	9.3	4.77
Swamp darter	25	25	0.0	0.03
Total	19988		81.4	
Littoral nets (n=2) for harvestable fish				
Yellow bullhead	0	0.0	0.0	0.00
Brown bullhead	0	0.0	0.0	0.00
Warmouth	56	30.9	5.6	3.04
Bluegill	25	0.0	2.0	0.00
Dollar sunfish	0	0.0	0.0	0.00
Redear sunfish	56	30.9	6.0	3.17
Largemouth bass	19	6.2	7.0	4.53
Total	154		20.5	

Table 211. (Concluded)

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Open-water nets (n=2) for total fish				
Florida gar	0	0	0.0	0.00
Golden shiner	0	0	0.0	0.00
Lake chubsucker	0	0	0.0	0.00
Yellow bullhead	6	6	0.0	0.02
Brown bullhead	19	19	0.1	0.08
Golden topminnow	0	0	0.0	0.00
Bluefin killifish	797	414	0.2	0.04
Tidewater silverside	0	0	0.0	0.00
Bluespotted sunfish	3106	352	2.0	0.64
Warmouth	1074	272	3.4	0.95
Bluegill	3964	1766	15.2	5.19
Dollar sunfish	4563	426	4.6	0.90
Redear sunfish	371	25	7.5	3.98
Largemouth bass	599	303	5.5	2.46
Swamp darter	105	105	0.0	0.04
Total	14604		38.5	
Open-water nets (n=2) for harvestable fish				
Yellow bullhead	0	0.0	0.0	0.00
Brown bullhead	0	0.0	0.0	0.00
Warmouth	0	0.0	0.0	0.00
Bluegill	12	0.0	1.7	0.67
Dollar sunfish	0	0.0	0.0	0.00
Redear sunfish	37	37.0	3.2	3.25
Largemouth bass	6	6.2	1.2	1.23
Total	56		6.1	

Table 212. Experimental gillnet (five 10-meter long sections of 1.9, 2.5, 3.8, 5.1, and 6.4 cm bar mesh, which were 2.4 meter deep) catch per unit effort estimates of total and harvestable fish number (number/net/24 hr) and weight (kg/net/24 hr) for Douglas. Mean values for experimental gillnets are listed by species with the corresponding standard error of the mean.

Common Name	Fish number (number/net/24 hr)	Standard Error	Fish weight (kg/net/24 hr)	Standard Error
Gillnets (n=3) for total fish				
Florida gar	10.0	2.65	3.9	1.54
Bowfin	0.3	0.33	0.5	0.50
Golden shiner	1.0	1.00	0.1	0.08
Lake chubsucker	1.3	0.33	0.5	0.18
Brown bullhead	0.3	0.33	0.2	0.21
Warmouth	0.7	0.33	0.0	0.02
Largemouth bass	5.7	1.33	2.0	0.76
Total	19.3		7.2	
Gillnets (n=3) for harvestable fish				
Brown bullhead	0.3	0.33	0.2	0.21
Warmouth	0.3	0.33	0.0	0.02
Largemouth bass	3.0	1.15	1.7	0.78
Total	3.7		1.9	

Table 213. Electrofishing catch per unit effort estimates of total and harvestable fish number (number/hr) and weight (kg/hr) for Douglas. Mean values are listed by species with the corresponding standard error of the mean.

Common Name	Number (number/hr)	Standard Error	Weight (kg/hr)	Standard Error
Electrofishing runs (n=4) for total fish				
Florida gar	1.5	1.50	10.1	1.01
Golden shiner	13.5	9.60	1.0	0.06
Lake chubsucker	97.5	24.30	137.7	3.59
Brown bullhead	1.5	1.50	10.5	1.05
Bluefin killifish	4.5	2.87	0.0	0.00
Brook silverside	4.5	2.87	0.0	0.00
Warmouth	9.0	5.74	3.6	0.21
Bluegill	150.0	34.55	8.1	0.17
Dollar sunfish	31.5	8.96	0.4	0.02
Redear sunfish	16.5	6.65	4.2	0.23
Largemouth bass	25.5	6.65	23.5	1.14
Total	355.5		198.9	
Electrofishing runs (n=4) for harvestable fish				
Brown bullhead	1.5	1.50	1.1	1.05
Warmouth	1.5	1.50	0.2	0.18
Bluegill	1.5	1.50	0.2	0.19
Dollar sunfish	0.0	0.00	0.0	0.00
Redear sunfish	3.0	1.73	0.3	0.14
Largemouth bass	4.5	2.87	1.5	1.08
Total	12.0		3.2	

Pasadena

Location and Morphology

Pasadena is located in Pasco County, Florida (Latitude 28.19 N; Longitude 82.13 W). The lake lies in the Dade City Hills division of the Ocala Uplift District (Brooks 1981). The geology is dominated by sand, silty sand and phosphatic clays of the Hawthorne Formation. Pasadena was sampled from 1989 to 1990 and had a surface area, shoreline length, and mean depth of 151 ha, 8.10 km and 3.1 m, respectively (Table 1).

Trophic Status and Water Chemistry

Pasadena had an average total phosphorus concentration of 15 µg/L and an average total nitrogen concentration of 702 µg/L. Total chlorophyll *a* concentrations averaged 3 µg/L and the water clarity as measured by use of a Secchi disc averaged 2.2 m (Table 2). The lake had an average pH of 7.8 and an average total alkalinity of 20 mg/L as $CaCO_3$. The average specific conductance was 245 µS/cm @ 25 C and the average water color was 19 Pt-Co units. The adjusted chlorophyll *a* value for Pasadena was 12.6 µg/L. Using this value and the classification system of Forsberg and Ryding (1980), Pasadena was classified as an eutrophic lake.

Aquatic Plants

Pasadena had a high abundance of aquatic macrophytes with a percent area coverage (PAC) and percent volume infested (PVI) with aquatic macrophytes of 73% and 62%, respectively (Table 3). The average above-ground biomass of emergent, floating-leaved and submersed vegetation was 2.4, 1.4 and 2.1 kg wet wt/m^2, respectively (Table 3). The average epiphytic algal concentration associated with the aquatic macrophytes was 12.3 mg chlorophyll *a*/cm^2 of host plant and 29.2 mg chlorophyll *a*/kg wet wt of host plant (Table 3). Twenty-one species of aquatic macrophytes were collected from Pasadena. The most commonly encountered plant species were *Eichhornia crassipes, Typha* spp., and *Sagittaria lancifolia,* which occurred in 90%, 90% and 80% of the transects, respectively (Table 214).

The plant community of Pasadena has been monitored by the Florida Department of Natural Resources from 1983 to present. The dominant macrophytes during that time were

Table 214. Occurrence of plant species in ten evenly-spaced transects around Lake Pasadena.

Common name	Scientific name	Percent of Transects
floating water-hyacinth	*Eichhornia crassipes*	90
duck-potato	*Sagittaria lancifolia*	80
alligator-weed	*Alternanthera philoxeroides*	10
banana-lily	*Nymphoides aquatica*	10
water-shield	*Brasenia schreberi*	10
spatterdock	*Nuphar luteum*	70
fragrant water-lily	*Nymphaea odorata*	50
pickerelweed	*Pontederia cordata*	60
cat-tail	*Typha* spp.	90
water-pennywort	*Hydrocotyle umbellata*	10
hydrilla	*Hydrilla verticillata*	60
purple fanwort	*Cabomba pulcherrima*	10
water primrose	*Ludwigia octovalis*	20
buttonbush	*Cephalanthus occidentalis*	10
willow	*Salix* spp.	10
maidencane	*Panicum hemitomon*	70
torpedograss	*Panicum repens*	30
soft rush	*Juncus effusus*	10
	Fuirena sciropoidea	10
	Utricularia foliosa	40
	Scirpus cubensis	70

Eichhornia crassipes, Typha spp. and *Panicum hemitomon* covering 1 to 10% of the lake's surface area. Hydrilla was first observed in Pasadena in 1983 (Florida Department of Natural Resources, unpublished data), but did not become a dominant plant until 1988 (Porak 1990). Thus, the fish population in Pasadena can be considered the product of an eutrophic lake with low levels of aquatic vegetation and a rapidly increasing level of hydrilla.

Invertebrates

The average number and biomass of epiphytic macroinvertebrates in Pasadena was 30 individuals/kg wet wt of host plant and 0.04 g wet wt/kg wet wt of host plant (Table 5). Average number and biomass of benthic macroinvertebrates in Pasadena, as estimated with a ponar dredge, was 7 individuals/m^2 and < 0.01 g wet wt/m^2 (Table 5). The zooplankton population in Pasadena was dominated by rotifers and nauplii with 126,000 and 113,000 individuals/m^3, respectively (Table 5).

Fish

Sixteen species of fish were collected in Pasadena (Table 215, 216 and 217). The most abundant species collected with rotenone sampling were warmouth and bluegill. These species had average standing stocks in littoral blocknets of 3,627 and 4,200 fish/ha, respectively (Table 215). The most abundant open-water species collected in the experimental gillnets were largemouth bass and golden shiner with 7 and 5 fish/net/24 hr, respectively (Table 216). The most abundant species collected using electrofishing were bluegill and largemouth bass with catch per unit efforts of 155 and 55 fish per hour, respectively (Table 217). Average first year growth of bluegill, redear sunfish, and largemouth bass was 59, 46, and 151 mm TL, respectively (Table 6). Mark-recapture estimates indicated that there were 42 harvestable largemouth bass per hectare in Pasadena (Table 7). No previous fisheries studies have been conducted on Pasadena.

Marianna

Location and Morphology

Marianna is located in Polk County, Florida (Latitude 28.04 N; Longitude 81.45 W). The lake lies in the Winter Haven Karst division of the Central Lake District (Brooks 1981). The geology is dominated by deeply weathered clayey sand of the Hawthorne Formation, and sand and clayey sands of the phosphatic Bone Valley Formation. Marianna was sampled from 1989 to 1990 and had a surface area, shoreline length, and mean depth of 204 ha, 6.22 km and 3.8 m, respectively (Table 1).

Trophic Status and Water Chemistry

Marianna had an average total phosphorus concentration of 26 µg/L and an average total nitrogen concentration of 1054 µg/L. Total chlorophyll *a* concentrations averaged 21 µg/L and the water clarity as measured by use of a Secchi disc averaged 1.3 m (Table 2). The lake had an average pH of 7.9 and an **(Text continued on page 451)**

Table 215. Blocknet-rotenone estimates of total and harvestable fish stock (number/hectare) and standing crop (kg/hectare) for Pasadena. Mean values for littoral and open-water nets are listed by species with the corresponding standard error of the mean.

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Littoral nets (n=3) for total fish				
Florida gar	4	4	0.0	0.02
Threadfin shad	0	0	0.0	0.00
Golden shiner	305	179	7.8	4.71
Lake chubsucker	86	33	12.3	1.72
Yellow bullhead	12	7	3.8	3.29
Brown bullhead	0	0	0.0	0.00
Golden topminnow	264	133	0.2	0.10
Flagfish	45	45	0.1	0.07
Mosquitofish	173	117	0.1	0.04
Brook silverside	0	0	0.0	0.00
Warmouth	3627	1171	19.7	5.96
Bluegill	4191	1994	30.8	18.00
Redear sunfish	630	246	8.0	2.65
Largemouth bass	1153	269	24.8	0.08
Black crappie	346	240	3.3	2.61
Swamp darter	152	112	0.1	0.04
Total	10987		110.9	
Littoral nets (n=3) for harvestable fish				
Yellow bullhead	8	8.2	3.4	3.44
Brown bullhead	0	0.0	0.0	0.00
Warmouth	29	17.9	2.7	1.87
Bluegill	78	65.9	8.0	7.06
Redear sunfish	0	0.0	0.0	0.00
Largemouth bass	37	0.0	18.5	1.67
Black crappie	4	4.1	0.7	0.73
Total	156		33.5	

Table 215. (Concluded)

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Open-water nets (n=3) for total fish				
Florida gar	0	0	0.0	0.00
Threadfin shad	12	7	0.1	0.05
Golden shiner	906	785	15.3	12.82
Lake chubsucker	33	15	20.4	10.41
Yellow bullhead	4	4	3.2	3.18
Brown bullhead	4	4	3.2	3.18
Golden topminnow	74	74	0.0	0.05
Flagfish	0	0	0.0	0.00
Mosquitofish	29	4	0.0	0.01
Brook silverside	8	4	0.0	0.00
Warmouth	395	190	1.7	0.94
Bluegill	3499	1116	52.1	6.09
Redear sunfish	119	58	1.7	0.25
Largemouth bass	1354	457	21.1	9.29
Black crappie	21	21	3.3	3.30
Swamp darter	17	16	0.0	0.01
Total	6476		122.2	
Open-water nets (n=3) for harvestable fish				
Yellow bullhead	4	4.1	3.2	3.18
Brown bullhead	4	4.1	3.2	3.18
Warmouth	0	0.0	0.0	0.00
Bluegill	148	99.1	17.1	11.15
Redear sunfish	4	4.1	0.4	0.40
Largemouth bass	25	7.1	15.4	9.83
Black crappie	8	8.2	3.3	3.26
Total	193		42.5	

Table 216. Experimental gillnet (five 10-meter long sections of 1.9, 2.5, 3.8, 5.1, and 6.4 cm bar mesh, which were 2.4 meter deep) catch per unit effort estimates of total and harvestable fish number (number/net/24 hr) and weight (kg/net/24 hr) for Pasadena. Mean values for experimental gillnets are listed by species with the corresponding standard error of the mean.

Common Name	Fish number (number/net/24 hr)	Standard Error	Fish weight (kg/net/24 hr)	Standard Error
Gillnets (n=3) for total fish				
Florida gar	4.3	0.88	3.0	0.88
Golden shiner	5.0	2.65	0.7	0.35
Lake chubsucker	4.0	2.65	2.7	1.86
Bluegill	3.0	1.53	0.2	0.14
Largemouth bass	7.0	3.21	3.3	1.86
Black crappie	4.7	2.03	0.4	0.16
Total	28.00		10.30	
Gillnets (n=3) for harvestable fish				
Bluegill	0.7	0.67	0.1	0.12
Largemouth bass	4.0	2.31	3.0	1.81
Black crappie	1.7	0.88	0.3	0.14
Total	6.3		3.4	

Table 217. Electrofishing catch per unit effort estimates of total and harvestable fish number (number/hr) and weight (kg/hr) for Pasadena. Mean values are listed by species with the corresponding standard error of the mean.

Common Name	Number (number/hr)	Standard Error	Weight (kg/hr)	Standard Error
Electrofishing runs (n=6) for total fish				
Florida gar	25.0	12.14	101.3	4.50
Threadfin shad	5.0	5.00	0.2	0.02
Golden shiner	9.0	6.88	1.1	0.08
Lake chubsucker	17.0	4.22	49.2	1.69
Golden topminnow	1.0	1.00	0.0	0.00
Mosquitofish	28.0	19.82	0.10	0.01
Warmouth	5.0	2.41	0.1	0.01
Bluegill	155.0	38.24	20.1	0.73
Redear sunfish	11.0	5.67	1.6	0.09
Largemouth bass	55.0	10.21	84.6	5.48
Swamp darter	1.0	1.00	0.0	0.00
Total	312.0		258.4	
Electrofishing runs (n=6) for harvestable fish				
Warmouth	0.0	0.00	0.0	0.00
Bluegill	7.0	5.88	0.7	0.62
Redear sunfish	1.0	1.00	0.1	0.10
Largemouth bass	8.0	2.97	8.1	5.54
Total	16.0		8.8	

average total alkalinity of 59 mg/L as $CaCO_3$. The average specific conductance was 299 µS/cm @ 25 C and the average water color was 16 Pt-Co units. The adjusted chlorophyll *a* value for Marianna was 22 µg/L. Using this value and the classification system of Forsberg and Ryding (1980), Marianna was classified as an eutrophic lake.

Aquatic Plants

Marianna had a moderate abundance of aquatic macrophytes with a percent area coverage (PAC) and percent volume infested (PVI) with aquatic macrophytes of 53% and 36%, respectively (Table 3). The average above-ground biomass of emergent, floating-leaved and submersed vegetation was 1.1, 0 and 1.1 kg wet wt/m^2, respectively (Table 3). The average epiphytic algal concentration associated with the aquatic macrophytes was 12.7 mg chlorophyll *a*/cm^2 of host plant and 31.1 mg chlorophyll *a*/kg wet wt of host plant (Table 3). Thirteen species of aquatic macrophytes were collected from Marianna. The most commonly encountered plant species were *Hydrilla verticillata, Potamogeton illinoensis,* and *Vallisneria americana* , which occurred in 100%, 100% and 80% of the transects, respectively (Table 218).

Table 218. Occurrence of plant species in ten evenly-spaced transects around Lake Marianna.

Common name	Scientific name	Percent of Transects
floating water-hyacinth	*Eichhornia crassipes*	10
spatterdock	*Nuphar luteum*	10
pickerelweed	*Pontederia cordata*	10
cat-tail	*Typha* spp.	70
water-pennywort	*Hydrocotyle umbellata*	20
coontail	*Ceratophyllum demersum*	30
hydrilla	*Hydrilla verticillata*	100
tapegrass	*Vallisneria americana*	80
Illinois pondweed	*Potamogeton illinoensis*	100
willow	*Salix* spp.	30
maidencane	*Panicum hemitomon*	40
torpedograss	*Panicum repens*	20
knot grass	*Paspalum distichum*	20

The plant community of Marianna has been monitored by the Florida Department of Natural Resources from 1983 to present. The major plants during that time were *Hydrilla verticillata* and *Potamogeton illinoensis.* These macrophytes covered from 1 to 20% and from 3 to 16% of the lake area, respectively. Thus, the fish population of Marianna can be considered the product of an eutrophic lake with moderate levels of aquatic vegetation.

Invertebrates

The average number and biomass of epiphytic macroinvertebrates in Marianna was 248 individuals/kg wet wt of host plant and 0.59 g wet wt/kg wet wt of host plant (Table 5). Average number and biomass of benthic macroinvertebrates in Marianna, as estimated with a ponar dredge, was 47 individuals/m^2 and 0.06 g wet wt/m^2 (Table 5). The zooplankton population in Marianna was dominated by rotifers and cladocerans with 267,000 and 149,000 individuals/m^3, respectively.

Fish

Twenty-one species of fish were collected from Marianna (Table 219, 220 and 221). The most abundant species collected with rotenone sampling were bluespotted sunfish and warmouth. These species had average standing stocks in littoral blocknets of 11,700 and 3,900 fish/ha, respectively (Table 219). The most abundant open-water species collected in the experimental gillnets were threadfin shad and largemouth bass with 11.3 and 10.7 fish/net/24 hr, respectively (Table 220). The most abundant species collected using electrofishing were the bluegill and threadfin shad with catch per unit efforts of 170 and 141 per hour, respectively (Table 221). Average first year growth of bluegill, redear sunfish, and largemouth bass was 83, 75, and 132 mm TL, respectively (Table 6). Mark-recapture estimates indicated that there were 91 harvestable bluegill, 1 harvestable redear sunfish and 22 harvestable largemouth bass per hectare (Table 7) in Lake Marianna. No previous fisheries data were available for Lake Marianna.

Mountain 2

Location and Morphology

Mountain 2 is located in Polk County, Florida (Latitude 27.56 N; Longitude 81.35 W). The lake lies in the Iron Mountain subdivision of the Lake Wales Ridge division of the Central Lake District (Brooks 1981). The geology is dominated by deeply weathered clayey sand, and clayey sands of the Hawthorne Formation. Mountain 2 was sampled from 1989 to 1990 and had a surface area, shoreline length and mean depth of 55 ha, 3.87 km and 3.3 m, respectively (Table 1). **(Text continued on page 458)**

Table 219. Blocknet-rotenone estimates of total and harvestable fish stock (number/hectare) and standing crop (kg/hectare) for Marianna. Mean values for littoral and open-water nets are listed by species with the corresponding standard error of the mean.

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Littoral nets (n=3) for total fish				
Florida gar	17	11	7.1	4.39
Gizzard shad	0	0	0.0	0.00
Threadfin shad	128	121	0.3	0.23
Golden shiner	21	21	0.2	0.23
Lake chubsucker	4	4	1.4	1.45
Brown bullhead	33	4	16.1	5.89
Golden topminnow	1005	277	0.6	0.16
Bluefin killifish	3495	1661	1.2	0.67
Mosquitofish	1840	532	0.6	0.17
Brook silverside	49	49	0.0	0.05
Bluespotted sunfish	11691	5749	11.3	5.67
Warmouth	3857	1334	34.0	6.62
Bluegill	3462	1268	44.5	14.29
Dollar sunfish	955	864	2.2	1.81
Redear sunfish	2371	691	33.3	11.74
Spotted sunfish	490	155	8.1	2.25
Largemouth bass	564	69	28.2	13.03
Swamp darter	37	37	0.0	0.01
Blue tilapia	37	7	55.0	8.88
Total	30056		244.2	
Littoral nets (n=3) for harvestable fish				
Brown bullhead	33	4.1	16.1	5.89
Warmouth	29	10.9	3.3	1.45
Bluegill	136	37.7	13.0	4.01
Dollar sunfish	0	0.0	0.0	0.00
Redear sunfish	16	8.2	1.7	0.91
Spotted sunfish	0	0.0	0.0	0.00
Largemouth bass	41	21.8	20.9	12.98
Total	255		55.0	

Table 219. (Concluded)

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Open-water nets (n=3) for total fish				
Florida gar	0	0	0.0	0.00
Gizzard shad	49	38	1.0	0.81
Threadfin shad	10913	8213	56.5	45.76
Golden shiner	111	111	1.6	1.61
Lake chubsucker	33	33	0.8	0.81
Brown bullhead	0	0	0.0	0.00
Golden topminnow	0	0	0.0	0.00
Bluefin killifish	148	148	0.1	0.08
Mosquitofish	0	0	0.0	0.00
Brook silverside	169	151	0.2	0.15
Bluespotted sunfish	2091	1879	3.5	3.44
Warmouth	276	276	2.8	2.84
Bluegill	2400	1678	40.9	21.99
Dollar sunfish	4	4	0.0	0.01
Redear sunfish	564	558	9.3	8.68
Spotted sunfish	66	66	2.0	2.03
Largemouth bass	91	35	10.0	6.92
Swamp darter	0	0	0.0	0.00
Blue tilapia	0	0	0.0	0.00
Total	16915		128.8	
Open-water nets (n=3) for harvestable fish				
Brown bullhead	0	0.0	0.0	0.00
Warmouth	0	0.0	0.0	0.00
Bluegill	29	10.9	2.3	1.02
Dollar sunfish	0	0.0	0.0	0.00
Redear sunfish	4	4.1	0.4	0.40
Spotted sunfish	0	0.0	0.0	0.00
Largemouth bass	16	10.9	8.7	6.79
Total	49		11.4	

Table 220. Experimental gillnet (five 10-meter long sections of 1.9, 2.5, 3.8, 5.1, and 6.4 cm bar mesh, which were 2.4 meter deep) catch per unit effort estimates of total and harvestable fish number (number/net/24 hr) and weight (kg/net/24 hr) for Marianna. Mean values for experimental gillnets are listed by species with the corresponding standard error of the mean.

Common Name	Fish number (number/net/24 hr)	Standard Error	Fish weight (kg/net/24 hr)	Standard Error
Gillnets (n=3) for total fish				
Florida gar	3.7	2.19	5.6	3.08
Gizzard shad	0.3	0.33	0.2	0.19
Threadfin shad	11.3	4.18	0.3	0.12
Golden shiner	9.7	6.23	0.6	0.41
Bluegill	8.3	2.96	0.3	0.17
Largemouth bass	10.7	6.49	5.1	3.30
Black crappie	5.0	2.65	0.6	0.13
Total	49.0		12.7	
Gillnets (n=3) for harvestable fish				
Bluegill	0.7	0.67	0.1	0.14
Largemouth bass	7.7	4.98	4.8	3.14
Black crappie	1.0	0.00	0.3	0.19
Total	9.3		5.3	

Table 221. Electrofishing catch per unit effort estimates of total and harvestable fish number (number/hr) and weight (kg/hr) for Marianna. Mean values are listed by species with the corresponding standard error of the mean.

Common Name	Number (number/hr)	Standard Error	Weight (kg/hr)	Standard Error
Electrofishing runs (n=6) for total fish				
Florida gar	9.0	2.57	38.6	1.33
Bowfin	1.0	1.00	7.5	0.75
Threadfin shad	141.0	74.71	3.9	0.21
Golden shiner	5.0	1.84	1.5	0.11
Lake chubsucker	10.0	2.53	28.0	1.05
Brown bullhead	4.0	2.00	15.3	0.73
Golden topminnow	2.0	1.26	0.10	0.00
Bluefin killifish	3.0	2.05	0.0	0.00
Brook silverside	2.0	1.26	0.0	0.00
Bluespotted sunfish	1.0	1.00	0.0	0.00
Warmouth	1.0	1.00	0.1	0.01
Bluegill	170.0	36.52	42.4	0.80
Dollar sunfish	1.0	1.00	0.0	0.00
Redear sunfish	62.0	21.61	12.0	0.36
Spotted sunfish	5.0	2.41	0.7	0.04
Largemouth bass	69.0	5.95	63.3	1.37
Total	486.0		213.4	
Electrofishing runs (n=6) for harvestable fish				
Brown bullhead	4.0	2.00	1.5	0.73
Warmouth	0.0	0.00	0.0	0.00
Bluegill	9.0	2.57	0.9	0.21
Dollar sunfish	0.0	0.00	0.0	0.00
Redear sunfish	4.0	2.00	0.4	0.24
Spotted sunfish	0.0	0.00	0.0	0.00
Largemouth bass	12.0	2.68	4.3	1.31
Total	29.0		7.1	

Trophic Status and Water Chemistry

Mountain 2 had an average total phosphorus concentration of 17 µg/L and an average total nitrogen concentration of 331 µg/L. Total chlorophyll *a* concentrations averaged 2 µg/L and the water clarity as measured by use of a Secchi disc averaged 2.4 m (Table 2). The lake had an average pH of 7.9 and an average total alkalinity of 82 mg/L as $CaCO_3$. The average specific conductance was 201 µS/cm @ 25 C and the average water color was 7 Pt-Co units. Using the classification system of Forsberg and Ryding (1980), Mountain 2 was classified as an oligotrophic lake during this study.

Aquatic Plants

Mountain 2 had a low abundance of aquatic macrophytes with a percent area coverage (PAC) and percent volume infested (PVI) with aquatic macrophytes of 13% and 4.6%, respectively (Table 3). The average above-ground biomass of emergent, floating-leaved and submersed vegetation was 0.9, 0 and 0.4 kg wet wt/m^2, respectively (Table 3). The average epiphytic algal concentration associated with the aquatic macrophytes was 15.8 mg chlorophyll *a*/cm^2 of host plant and 34.6 mg chlorophyll *a*/kg wet wt of host plant (Table 3). Twelve species of aquatic macrophytes were collected in Mountain 2. The most commonly encountered plant species were *Potamogeton illinoensis, Typha* spp. and *Panicum hemitomon,* which occurred in 100%, 60% and 60% of the transects, respectively (Table 222).

No previous vegetation studies have been conducted on Mountain 2. Mountain 2 is a private lake and the residents who live on the lake agree that no major change in the plant community has occurred over the last several years. Thus, the fish population in Mountain 2 can be considered the product of an oligotrophic lake with low levels of aquatic vegetation.

Invertebrates

The average number and biomass of epiphytic macroinvertebrates in Mountain 2 was 239 individuals/kg wet wt of host plant and 13.5 g wet wt/kg wet wt of host plant (Table 5). Average number and biomass of benthic macroinvertebrates in Mountain 2, as estimated with a ponar dredge, was 160 individuals/m^2 and 77.3 g wet wt/m^2, respectively (Table 5). The zooplankton population in Mountain 2 was dominated by nauplii and cladocerans with

Table 222. Occurrence of plant species in ten evenly-spaced transects around Mountain Lake.

Common name	Scientific name	Percent of Transects
duck-potato	*Sagittaria lancifolia*	40
baby-tears	*Micranthemum umbrosum*	10
cat-tail	*Typha* spp.	60
water-pennywort	*Hydrocotyle umbellata*	10
Illinois pondweed	*Potamogeton illinoensis*	100
wax myrtle	*Myrica ceriferia*	10
water primrose	*Ludwigia octovalis*	10
willow	*Salix* spp.	40
maidencane	*Panicum hemitomon*	60
torpedograss	*Panicum repens*	60
	Fuirena sciropoidea	20
	Eleocharis cellulosa	10

23,800 and 11,600 individual/m^3, respectively (Table 5).

Fish

Seventeen species of fish were collected in Mountain 2 (Table 223, 224 and 225). The most abundant species collected with rotenone sampling were redear sunfish and bluegill. These species had average standing stocks in littoral blocknets of 2,600 and 2,200 fish/ha, respectively (Table 223). The most abundant open-water species collected in the experimental gillnets were Florida gar and lake chubsucker with 2.3 and 0.7 fish/net/24 hr, respectively (Table 224). The most abundant species collected using electrofishing were bluegill and redear sunfish with catch per unit efforts of 132 and 93 fish per hour, respectively (Table 225). Average first year growth of bluegill, redear sunfish and largemouth bass was 44, 71, and 150 mm TL, respectively (Table 6). Mark-recapture estimates indicated that there were 59 harvestable bluegill, 55 harvestable redear sunfish, and 17 harvestable largemouth bass per hectare in Mountain 2 (Table 7). No previous data on the fish population of Mountain 2 were available. **(Text continued on page 463)**

Table 223. Blocknet-rotenone estimates of total and harvestable fish stock (number/hectare) and standing crop (kg/hectare) for Mountain 2. Mean values for littoral and open-water nets are listed by species with the corresponding standard error of the mean.

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Littoral nets (n=3) for total fish				
Florida gar	12	7	9.9	5.42
Threadfin shad	0	0	0.0	0.00
Golden shiner	29	29	2.5	2.47
Lake chubsucker	107	76	9.5	7.39
Yellow bullhead	391	303	5.1	3.10
Brown bullhead	4	4	0.3	0.33
Golden topminnow	515	332	0.5	0.25
Seminole killifish	95	89	0.3	0.23
Mosquitofish	1157	681	0.6	0.43
Least killifish	206	104	0.0	0.01
Sailfin molly	189	189	0.3	0.26
Brook silverside	1811	1444	1.7	1.39
Warmouth	1272	303	6.7	1.89
Bluegill	2190	1054	47.8	13.06
Redear sunfish	2577	623	67.0	24.11
Largemouth bass	943	89	40.9	4.58
Swamp darter	395	154	0.1	0.06
Total	11893		193.4	
Littoral nets (n=3) for harvestable fish				
Yellow bullhead	0	0.0	0.0	0.00
Brown bullhead	0	0.0	0.0	0.00
Warmouth	4	4.1	0.4	0.42
Bluegill	91	20.6	7.1	1.56
Redear sunfish	432	187.0	48.5	17.83
Largemouth bass	86	0.0	31.9	4.41
Total	613		87.9	

Table 223. (Concluded)

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Open-water nets (n=3) for total fish				
Florida gar	0	0	0.0	0.00
Threadfin shad	21	11	0.0	0.02
Golden shiner	0	0	0.0	0.00
Lake chubsucker	0	0	0.0	0.00
Yellow bullhead	0	0	0.0	0.00
Brown bullhead	0	0	0.0	0.00
Golden topminnow	0	0	0.0	0.00
Seminole killifish	4	4	0.0	0.01
Mosquitofish	0	0	0.0	0.00
Least killifish	0	0	0.0	0.00
Sailfin molly	0	0	0.0	0.00
Brook silverside	1144	994	0.9	0.85
Warmouth	0	0	0.0	0.00
Bluegill	4	4	0.2	0.17
Redear sunfish	33	18	5.9	3.49
Largemouth bass	21	15	3.5	2:36
Swamp darter	29	29	0.0	0.01
Total	1256		10.5	
Open-water nets (n=3) for harvestable fish				
Yellow bullhead	0	0.0	0.0	0.00
Brown bullhead	0	0.0	0.0	0.00
Warmouth	0	0.0	0.0	0.00
Bluegill	0	0.0	0.0	0.00
Redear sunfish	21	10.9	5.8	3.42
Largemouth bass	12	7.1	3.0	1.89
Total	33		8.8	

Table 224. Experimental gillnet (five 10-meter long sections of 1.9, 2.5, 3.8, 5.1, and 6.4 cm bar mesh, which were 2.4 meter deep) catch per unit effort estimates of total and harvestable fish number (number/net/24 hr) and weight (kg/net/24 hr) for Mountain 2. Mean values for experimental gillnets are listed by species with the corresponding standard error of the mean.

Common Name	Fish number (number/net/24 hr)	Standard Error	Fish weight (kg/net/24 hr)	Standard Error
Gillnets (n=3) for total fish				
Florida gar	2.3	1.20	1.8	0.93
Golden shiner	0.7	0.33	0.1	0.04
Lake chubsucker	0.7	0.67	0.2	0.16
Bluegill	0.3	0.33	0.0	0.01
Largemouth bass	0.3	0.33	0.1	0.11
Total	4.33		2.20	
Gillnets (n=3) for harvestable fish				
Bluegill	0.0	0.00	0.0	0.00
Largemouth bass	0.3	0.33	0.1	0.11
Total	0.3		0.1	

Table 225. Electrofishing catch per unit effort estimates of total and harvestable fish number (number/hr) and weight (kg/hr) for Mountain 2. Mean values are listed by species with the corresponding standard error of the mean.

Common Name	Number (number/hr)	Standard Error	Weight (kg/hr)	Standard Error
Electrofishing runs (n=4) for total fish				
Florida gar	3.0	1.73	12.7	0.78
Golden shiner	1.5	1.50	0.2	0.02
Lake chubsucker	13.5	4.50	18.0	0.30
Brook silverside	3.0	3.00	0.0	0.00
Bluegill	132.0	36.08	29.2	0.42
Redear sunfish	93.0	29.03	46.1	1.38
Largemouth bass	69.0	16.34	65.6	2.22
Total	315.0		171.7	
Electrofishing runs (n=4) for harvestable fish				
Bluegill	12.0	4.90	0.9	0.41
Redear sunfish	33.0	11.09	3.9	1.25
Largemouth bass	9.0	3.00	4.9	2.21
Total	54.0		9.7	

Gate Lake

Location and Morphology

Gate Lake is located in Polk County, Florida (Latitude 27.56 N; Longitude 81.36 W). The lake lies in the Iron Mountain subdivision of the Lake Wales Ridge division of the Central Lake District (Brooks 1981). The geology is dominated by deeply weathered clayey sand and clayey sands of the Hawthorne Formation. Gate Lake was sampled from 1989 to 1990 and had a surface area, shoreline length, and mean depth of 7.8 ha, 1.43 km and 1.8 m, respectively (Table 1).

Trophic Status and Water Chemistry

Gate Lake had an average total phosphorus concentration of 28 µg/L and an average total nitrogen concentration of 407 µg/L. Total chlorophyll *a* concentrations averaged 20 µg/L and the water clarity as measured by use of a Secchi disc averaged 1.1 m (Table 2). The lake had an average pH of 8.2 and an average total alkalinity of 131 mg/L as $CaCO_3$. The average specific conductance was 282 µS/cm @ 25 C and the average water color was 6 Pt-Co units. Using the classification system of Forsberg and Ryding (1980), Gate Lake was classified as an eutrophic lake.

Aquatic Plants

Gate Lake had a moderate abundance of aquatic macrophytes with a percent area coverage (PAC) and percent volume infested (PVI) with aquatic macrophytes of 37% and 18%, respectively (Table 3). The average above-ground biomass of emergent, floating-leaved and submersed vegetation was 0.9, 0 and 0.2 kg wet wt/m^2, respectively (Table 3). Thirteen species of aquatic macrophytes were collected from Gate Lake. The most commonly encountered plant species were *Bacopa monnieri, Ludwigia octovalis* and *Hydrocotyle umbellata*, which occurred in 100%, 90% and 80% of the transects, respectively (Table 226).

No previous vegetation studies have been conducted on Gate Lake. Gate Lake is a private lake and the residents who live on the lake agree that no major change in the plant community has occurred over the last several years. Thus, the fish population in Gate Lake can be considered the product of an eutrophic lake with low levels of aquatic vegetation.

Invertebrates

The average number and biomass of epiphytic macroinvertebrates in Gate Lake was 40 individuals/kg wet wt of host plants and 0.59 g wet wt/kg wet wt of host plant (Table 5). Average number and biomass of benthic macroinvertebrates in Gate Lake, as estimated with a ponar dredge, was 647 individuals/m^2 and 23.7 g wet wt/m^2 (Table 5). The zooplankton population in Gate Lake was dominated by rotifers and nauplii with 41,400 and 20,400 individuals/m^3, respectively (Table 5).

Table 226. Occurrence of plant species in ten evenly-spaced transects around Gate Lake.

Common name	Scientific name	Percent of Transects
slender spikerush	*Eleocharis baldwinii*	30
pickerelweed	*Pontederia cordata*	20
bacopa	*Bacopa monnieri*	100
baby-tears	*Micranthemum umbrosum*	10
cat-tail	*Typha* spp.	30
water-pennywort	*Hydrocotyle umbellata*	80
water primrose	*Ludwigia octovalis*	90
giant bulrush	*Scirpus californicus*	30
maidencane	*Panicum hemitomon*	30
para grass	*Brachiaria mutica*	10
	Fuirena sciropoidea	10
	Leersia hexandra	80
hatpin	*Eriocaulon decangulare*	40

Fish

Fourteen species of fish were collected in Gate Lake (Table 227, 228, and 229). The most abundant species collected with rotenone sampling were seminole killifish and threadfin shad. These species had average standing stocks in littoral blocknets of 1,800 and 1,400 fish/ha, respectively (Table 227). The most abundant open-water species collected in the experimental gillnets were lake chubsucker and largemouth bass with 8.3 and 7 fish/net/24 hr, respectively (Table 228). The most abundant species collected using electrofishing were the bluegill and redear sunfish with catch per unit efforts of 98 and 74 per hour, respectively (Table 229). Average first year growth of bluegill, redear sunfish and largemouth bass was 57, 69, and 199 mm TL, respectively (Table 6). Mark-recapture estimates indicated that there were 31 harvestable bluegill, 237 harvestable redear sunfish, and 23 harvestable largemouth bass per hectare (Table 7) in Gate Lake. No previous data on the fish population of Gate Lake were available. **(Text continued on page 469)**

Table 227. Blocknet-rotenone estimates of total and harvestable fish stock (number/hectare) and standing crop (kg/hectare) for Gate Lake. Mean values for littoral and open-water nets are listed by species with the corresponding standard error of the mean.

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Littoral nets (n=2) for total fish				
Florida gar	0	0	0.0	0.00
Threadfin shad	1396	1383	2.7	2.69
Seminole killifish	1766	1223	9.2	6.31
Mosquitofish	93	93	0.0	0.03
Sailfin molly	247	247	0.4	0.37
Brook silverside	117	105	0.1	0.10
Bluegill	790	469	9.5	1.21
Redear sunfish	815	469	51.3	28.87
Largemouth bass	130	19	9.0	1.77
Black crappie	0	0	0.0	0.00
Total	5354		82.3	
Open-water nets (n=2) for total fish				
Florida gar	6	6	5.6	5.60
Threadfin shad	14814	14604	31.3	30.90
Seminole killifish	191	19	0.2	0.04
Mosquitofish	0	0	0.0	0.00
Sailfin molly	0	0	0.0	0.00
Brook silverside	49	49	0.0	0.02
Bluegill	56	43	0.7	0.31
Redear sunfish	692	333	6.1	5.52
Largemouth bass	25	0	6.8	4.21
Black crappie	6	6	3.4	3.40
Total	15839		54.1	

Table 227. (Concluded)

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Littoral nets (n=2) for harvestable fish				
Bluegill	25	0.0	2.1	0.12
Redear sunfish	309	222.3	39.5	27.72
Largemouth bass	12	0.0	4.1	0.08
Black crappie	0	0.0	0.0	0.00
Total	346		45.7	
Open-water nets (n=2) for harvestable fish				
Bluegill	6	6.2	0.5	0.49
Redear sunfish	37	37.0	5.5	5.54
Largemouth bass	19	6.2	6.7	4.28
Black crappie	6	6.2	3.4	3.40
Total	68		16.2	

Table 228. Experimental gillnet (five 10-meter long sections of 1.9, 2.5, 3.8, 5.1, and 6.4 cm bar mesh, which were 2.4 meter deep) catch per unit effort estimates of total and harvestable fish number (number/net/24 hr) and weight (kg/net/24 hr) for Gate Lake. Mean values for experimental gillnets are listed by species with the corresponding standard error of the mean.

Common Name	Fish number (number/net/24 hr)	Standard Error	Fish weight (kg/net/24 hr)	Standard Error
Gillnets (n=3) for total fish				
Florida gar	3.3	1.45	3.0	1.25
Golden shiner	2.7	2.19	0.3	0.21
Lake chubsucker	8.3	2.19	4.9	1.53
Bluegill	1.0	0.58	0.0	0.02
Redear sunfish	0.7	0.67	0.1	0.09
Largemouth bass	7.0	1.00	2.8	0.61
Black crappie	1.0	0.58	0.4	0.29
Total	24.00		11.65	
Gillnets (n=3) for harvestable fish				
Bluegill	0.0	0.00	0.0	0.00
Redear sunfish	0.7	0.67	0.1	0.09
Largemouth bass	6.7	1.20	2.8	0.64
Black crappie	1.0	0.58	0.4	0.29
Total	8.3		3.3	

Table 229. Electrofishing catch per unit effort estimates of total and harvestable fish number (number/hr) and weight (kg/hr) for Gate Lake. Mean values are listed by species with the corresponding standard error of the mean.

Common Name	Number (number/hr)	Standard Error	Weight (kg/hr)	Standard Error
Electrofishing runs (n=3) for total fish				
Florida gar	2.0	2.00	11.6	1.16
Threadfin shad	6.0	6.00	0.0	0.00
Golden shiner	28.0	28.00	25.3	2.53
Seminole killifish	12.0	3.46	0.4	0.02
Sailfin molly	2.0	2.00	0.0	0.00
Warmouth	2.0	2.00	0.10	0.01
Bluegill	98.0	39.85	23.9	0.66
Redear sunfish	74.0	23.07	48.3	2.04
Largemouth bass	44.0	16.00	122.2	5.87
Total	268.0		231.9	
Electrofishing runs (n=3) for harvestable fish				
Warmouth	0.0	0.00	0.0	0.00
Bluegill	6.0	3.46	0.7	0.42
Redear sunfish	28.0	14.00	3.8	1.94
Largemouth bass	14.0	7.21	10.3	5.13
Total	48.0		14.8	

Thomas

Location and Morphology

Thomas is located in Polk County, Florida (Latitude 28.00 N; Longitude 81.46 W). The lake lies in the Winter Haven Karst division of the Central Lake District (Brooks 1981). The geology is dominated by deeply weathered clayey sand and clayey sands of the Hawthorne Formation. Thomas was sampled from 1989 to 1990 and had a surface area, shoreline length, and mean depth of 55 hectares, 1.71 km and 3.9 m, respectively (Table 1).

Trophic Status and Water Chemistry

Thomas had an average total phosphorus concentration of 22 µg/L and an average total nitrogen concentration of 759 µg/L. Total chlorophyll *a* concentrations averaged 10 µg/L and the water clarity as measured by use of a Secchi disc averaged 1.8 m (Table 2). The lake had an average pH of 7.6 and an average total alkalinity of 46.6 mg/L as $CaCO_3$. The average specific conductance was 169 µS/cm @ 25 C and the average water color was 23 Pt-Co units. Using the classification system of Forsberg and Ryding (1980), Thomas was classified as an eutrophic lake.

Aquatic Plants

Thomas had a low abundance of aquatic macrophytes with a percent area coverage (PAC) and percent volume infested (PVI) with aquatic macrophytes of 6.7% and 0.5%, respectively (Table 3). The average above-ground biomass of emergent, floating-leaved and submersed vegetation was 1.2, 0 and 1.2 kg wet wt/m^2, respectively (Table 3). The average epiphytic algal concentration associated with the aquatic macrophytes was 23.4 mg chlorophyll *a*/cm^2 of host plant and 44.7 mg chlorophyll *a*/kg wet wt of host plant (Table 3). Thirteen species of aquatic macrophytes were collected from Thomas. The most commonly encountered plant species Typha spp., *Ceratophyllum demersum,* and *Pontederia cordata* , which occurred in 100%, 80% and 70% of the transects, respectively (Table 230).

A band of Typha spp. about 25 m wide encircles most of Thomas and many homes on the lake keep a maximum of 15.2 m cleared to the shoreline. The residents agree that no major change in the vegetation has occurred over the last several years. Thus, the fish population in Thomas can be considered the product of an eutrophic lake with low levels of vegetation.

Invertebrates

The average number and biomass of epiphytic macroinvertebrates in Thomas was 316 individuals/kg wet wt of host plant and 0.65 g wet wt/kg wet wt of host plant (Table 5). Average number and biomass of benthic macroinvertebrates in Thomas, as estimated with a ponar dredge, was 27 individuals/m^2 and 0.28 g wet wt/m^2, respectively (Table 5). The

Table 230. Occurrence of plant species in ten evenly-spaced transects around Lake Thomas.

Common name	Scientific name	Percent of Transects
duck-potato	*Sagittaria lancifolia*	10
pickerelweed	*Pontederia cordata*	70
baby-tears	*Micranthemum umbrosum*	70
cat-tail	*Typha* spp.	100
water-pennywort	*Hydrocotyle umbellata*	10
coontail	*Ceratophyllum demersum*	80
hydrilla	*Hydrilla verticillata*	10
water primrose	*Ludwigia octovalis*	60
willow	*Salix* spp.	20
giant bulrush	*Scirpus californicus*	10
maidencane	*Panicum hemitomon*	10
torpedograss	*Panicum repens*	60
musk-grass	*Chara* spp.	10

zooplankton population in Thomas was dominated by cladocerans and nauplii with 63,000 and 40,300 individual/m^3, respectively (Table 5).

Fish

Thirteen species of fish were collected from Thomas (Table 231, 232 and 233). The most abundant species collected with rotenone sampling were bluegill and warmouth. These species had average standing stocks in littoral blocknets of 23,200 and 5,500 fish/ha, respectively (Table 231). The most abundant open-water species collected in the experimental gillnets were bluegill and black crappie with 27.3 and 7.3 fish/net/24 hr, respectively (Table 232). The most abundant species collected using electrofishing were largemouth bass and bluegill with catch per unit efforts of 128, and 58 fish per hour, respectively (Table 233). Average first year growth of bluegill, redear sunfish, and largemouth bass was 69, 64, and 140 mm TL, respectively (Table 6). Mark-recapture estimates indicated that there were 15 harvestable bluegill, 6 harvestable redear sunfish, and 13 harvestable largemouth bass per hectare in Lake Thomas (Table 7). No previous data on the fish population in Thomas were available. **(Text continued on page 475)**

Table 231. Blocknet-rotenone estimates of total and harvestable fish stock (number/hectare) and standing crop (kg/hectare) for Thomas. Mean values for littoral and open-water nets are listed by species with the corresponding standard error of the mean.

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Littoral nets (n=2) for total fish				
Golden shiner	241	241	1.1	1.08
Seminole killifish	161	136	0.7	0.54
Mosquitofish	222	222	0.1	0.07
Least killifish	56	56	0.0	0.01
Warmouth	5539	5057	21.9	16.51
Bluegill	23150	10244	40.1	4.29
Redear sunfish	1204	438	31.7	1.03
Largemouth bass	198	12	30.2	22.34
Black crappie	111	111	14.0	14.00
Swamp darter	321	123	0.1	0.04
Blue tilapia	111	12	7.0	6.50
Total	31313		146.9	
Open-water nets (n=2) for total fish				
Golden shiner	0	0	0.0	0.00
Seminole killifish	0	0	0.0	0.00
Mosquitofish	0	0	0.0	0.00
Least killifish	0	0	0.0	0.00
Warmouth	12	12	0.0	0.04
Bluegill	593	185	33.9	20.58
Redear sunfish	12	12	0.5	0.53
Largemouth bass	43	19	9.4	6.40
Black crappie	0	0	0.0	0.00
Swamp darter	6	6	0.0	0.00
Blue tilapia	25	0	20.7	7.91
Total	692		64.6	

Table 231. (Concluded)

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Littoral nets (n=2) for harvestable fish				
Warmouth	0	0.0	0.0	0.00
Bluegill	31	30.9	2.5	2.47
Redear sunfish	80	43.2	7.5	2.82
Largemouth bass	37	24.7	21.4	18.97
Black crappie	93	92.6	12.8	12.80
Total	241		44.2	
Open-water nets (n=2) for harvestable fish				
Warmouth	0	0.0	0.0	0.00
Bluegill	414	265.5	32.2	21.51
Redear sunfish	6	6.2	0.4	0.43
Largemouth bass	25	12.3	7.6	5.31
Black crappie	0	0.0	0.0	0.00
Total	445		40.2	

Table 232. Experimental gillnet (five 10-meter long sections of 1.9, 2.5, 3.8, 5.1, and 6.4 cm bar mesh, which were 2.4 meter deep) catch per unit effort estimates of total and harvestable fish number (number/net/24 hr) and weight (kg/net/24 hr) for Thomas. Mean values for experimental gillnets are listed by species with the corresponding standard error of the mean.

Common Name	Fish number (number/net/24 hr)	Standard Error	Fish weight (kg/net/24 hr)	Standard Error
Gillnets (n=3) for total fish				
Yellow bullhead	0.3	0.33	0.1	0.10
Brown bullhead	0.7	0.67	0.4	0.38
Bluegill	27.3	4.10	2.5	0.29
Largemouth bass	0.7	0.33	0.5	0.24
Black crappie	7.3	5.46	1.3	0.97
Blue tilapia	0.7	0.33	0.6	0.28
Total	37.00		5.34	
Gillnets (n=3) for harvestable fish				
Yellow bullhead	0.3	0.33	0.1	0.10
Brown bullhead	0.7	0.67	0.4	0.38
Bluegill	20.3	2.96	2.2	0.23
Largemouth bass	0.7	0.33	0.5	0.24
Black crappie	7.3	5.46	1.3	0.97
Total	29.3		4.5	

Table 233. Electrofishing catch per unit effort estimates of total and harvestable fish number (number/hr) and weight (kg/hr) for Thomas. Mean values are listed by species with the corresponding standard error of the mean.

Common Name	Number (number/hr)	Standard Error	Weight (kg/hr)	Standard Error
Electrofishing runs (n=3) for total fish				
Golden shiner	34.0	31.05	2.7	0.26
Seminole killifish	14.0	14.00	0.8	0.08
Mosquitofish	2.0	2.00	0.0	0.00
Bluegill	58.0	19.70	36.2	0.80
Redear sunfish	60.0	15.87	30.2	0.80
Largemouth bass	128.0	24.33	180.2	6.93
Total	296.0		250.0	
Electrofishing runs (n=3) for harvestable fish				
Bluegill	30.0	9.17	3.0	1.10
Redear sunfish	20.0	8.00	1.8	0.96
Largemouth bass	18.0	9.17	9.5	5.98
Total	68.0		14.4	

Little Fish

Location and Morphology

Little Fish is located in Putnam County, Florida (Latitude 29.31 N; Longitude 81.59 W). The lake lies in the St. Johns Offset division of the Central Lake District (Brooks 1981). The geology is dominated by deeply weathered clayey sand and clayey sands of the Hawthorne Formation. Little Fish was sampled from 1989 to 1990 and had a surface area, shoreline length, and mean depth of 1.8 ha, 0.60 km and 1.3 m, respectively (Table 1).

Trophic Status and Water Chemistry

Little Fish had an average total phosphorus concentration of 21 µg/L and an average total nitrogen concentration of 1161 µg/L. Total chlorophyll *a* concentrations averaged 13 µg/L and the water clarity as measured by use of a Secchi disc averaged 1.4 m (Table 2). The lake had an average pH of 6.8 and an average total alkalinity of 32 mg/L as $CaCO_3$. The average specific conductance was 83 µS/cm @ 25 C and the average water color was 29 Pt-Co units. The adjusted chlorophyll *a* value for Little Fish was 31.9 µg/L. Using this value and the classification system of Forsberg and Ryding (1980), Little Fish was an eutrophic lake during this study.

Aquatic Plants

Little Fish had a high abundance of aquatic macrophytes with a percent area coverage (PAC) and percent volume infested (PVI) with aquatic macrophytes of 80% and 31%, respectively (Table 3). The average above-ground biomass of emergent, floating-leaved and submersed vegetation was 0.7, 0.3 and 1.1 kg wet wt/m^2, respectively (Table 3). The average epiphytic algal concentration associated with the aquatic macrophytes was 30.6 mg chlorophyll *a*/cm^2 of host plant and 11.1 mg chlorophyll *a*/kg wet wt of host plant (Table 3). Nine species of aquatic macrophytes were collected from Little Fish. The most commonly encountered plant species were *Nuphar luteum, Panicum hemitomon,* and *Xyris* spp., which occurred in 100%, 100% and 80% of the transects, respectively (Table 234).

No previous vegetation studies have been conducted on Little Fish, but Little Fish is a private lake on undeveloped land. The owner (Mr. Jack Williams Gainesville, Florida) and his land caretaker both agree the lake's vegetation and general appearance has remained the same for several years prior to our sampling. Thus, the fish population in Little Fish can be considered the product of an eutrophic lake with a moderate level of aquatic vegetation.

Invertebrates

The average number and biomass of epiphytic macroinvertebrates in Little Fish was 160 individuals/kg wet wt of host plant and 0.79 g wet wt/kg wet wt of host plant (Table 5). Average number and biomass of benthic macroinvertebrates in Little Fish, as estimated with a ponar dredge, was 320 individuals/m^2 and 0.29 g wet wt/m^2, respectively (Table 5).

Table 234. Occurrence of plant species in ten evenly-spaced transects around Little Fish Pond.

Common name	Scientific name	Percent of Transects
slender spikerush	*Eleocharis baldwinii*	60
spatterdock	*Nuphar luteum*	100
red ludwigia	*Ludwigia repens*	40
water-pennywort	*Hydrocotyle umbellata*	80
bog-moss	*Mayaca fluviatilis*	20
maidencane	*Panicum hemitomon*	100
	Rhynchospora inundata	40
yellow-eyed grass	*Xyris* spp.	90
	Eleocharis elongata	40

The zooplankton population in Little Fish was dominated by rotifers and nauplii with 53,900 and 44,300 individuals/m^3, respectively (Table 5).

<u>Fish</u>

Eight species of fish were collected from Little Fish (Table 235, 236 and 237). The most abundant species collected with rotenone sampling were bluegill and warmouth. These species had average standing stocks in littoral blocknets of 23,200 and 5,700 fish/ha, respectively (Table 235). The most abundant open-water species collected in the experimental gillnets were largemouth bass and bluegill with 4 and 1 fish/net/24 hr, respectively (Table 236). The most abundant species collected using electrofishing were bluegill and largemouth bass with catch per unit efforts of 294 and 24 fish per hour, respectively (Table 237). Average first-year growth of bluegill, redear sunfish, and largemouth bass was 53, 95, and 152 mm TL, respectively (Table 6). Mark-recapture estimates indicated that there were 797 harvestable bluegill, 80 harvestable redear sunfish, and 75 harvestable largemouth bass per hectare in Little Fish (Table 7).

No previous fisheries studies have been done on Little Fish, but Little Fish is a private lake on undeveloped land and the owner (Mr. Jack Williams of Gainesville, Florida) and his land caretaker have observed no major change in the fish population over the last several years. **(Text continued on page 481)**

Table 235. Blocknet-rotenone estimates of total and harvestable fish stock (number/hectare) and standing crop (kg/hectare) for Little Fish. Mean values for littoral and open-water nets are listed by species with the corresponding standard error of the mean.

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Littoral nets (n=1) for total fish				
Golden shiner	12	0	2.0	0.00
Mosquitofish	296	0	0.2	0.00
Warmouth	5743	0	18.1	0.00
Bluegill	23206	0	141.6	0.00
Redear sunfish	568	0	7.7	0.00
Largemouth bass	803	0	80.8	0.00
Total	30628		250.5	
Open-water nets (n=1) for total fish				
Golden shiner	0	0	0.0	0.00
Mosquitofish	0	0	0.0	0.00
Warmouth	173	0	0.3	0.00
Bluegill	692	0	12.4	0.00
Redear sunfish	12	0	0.2	0.00
Largemouth bass	12	0	0.4	0.00
Total	889		13.3	

Table 235. (Concluded)

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Littoral nets (n=1) for harvestable fish				
Warmouth	12	0.0	1.3	0.00
Bluegill	124	0.0	13.1	0.00
Redear sunfish	62	0.0	6.0	0.00
Largemouth bass	111	0.0	75.1	0.00
Total	309		95.4	
Open-water nets (n=1) for harvestable fish				
Warmouth	0	0.0	0.0	0.00
Bluegill	49	0.0	3.7	0.00
Redear sunfish	0	0.0	0.0	0.00
Largemouth bass	0	0.0	0.0	0.00
Total	49		3.7	

Table 236. Experimental gillnet (five 10-meter long sections of 1.9, 2.5, 3.8, 5.1, and 6.4 cm bar mesh, which were 2.4 meter deep) catch per unit effort estimates of total and harvestable fish number (number/net/24 hr) and weight (kg/net/24 hr) for Little Fish. Mean values for experimental gillnets are listed by species with the corresponding standard error of the mean.

Common Name	Fish number (number/net/24 hr)	Standard Error	Fish weight (kg/net/24 hr)	Standard Error
Gillnets (n=1) for total fish				
Golden shiner	1.0	0.00	0.3	0.00
Brown bullhead	1.0	0.00	0.9	0.00
Bluegill	1.0	0.00	0.0	0.00
Largemouth bass	4.0	0.00	2.4	0.00
Black crappie	1.0	0.00	0.0	0.00
Total	8.00		3.62	
Gillnets (n=1) for harvestable fish				
Brown bullhead	1.0	0.00	0.9	0.00
Bluegill	0.0	0.00	0.0	0.00
Largemouth bass	3.0	0.00	2.3	0.00
Black crappie	0.0	0.00	0.0	0.00
Total	4.0		3.2	

Table 237. Electrofishing catch per unit effort estimates of total and harvestable fish number (number/hr) and weight (kg/hr) for Little Fish. Mean values are listed by species with the corresponding standard error of the mean.

Common Name	Number (number/hr)	Standard Error	Weight (kg/hr)	Standard Error
Electrofishing runs (n=3) for total fish				
Bluegill	294.0	57.03	30.5	0.21
Redear sunfish	2.0	2.00	1.3	0.13
Largemouth bass	24.0	12.49	103.1	7.89
Total	320.0		134.9	
Electrofishing runs (n=3) for harvestable fish				
Bluegill	4.0	4.00	0.4	0.36
Redear sunfish	0.0	0.00	0.0	0.00
Largemouth bass	18.0	12.49	10.1	7.98
Total	22.0		10.5	

Picnic

Location and Morphology

Picnic is located in Putnam County, Florida (Latitude 29.30 N; Longitude 81.58 W) The lake lies in the St. Johns Offset division of the Central Lake District (Brooks 1981). The geology is dominated by deeply weathered clayey sand and clayey sands of the Hawthorne Formation. Picnic was sampled from 1989 to 1990 and had a surface area, shoreline length, and mean depth of 18 ha, 1.89 km, and 3.3 m, respectively (Table 1).

Trophic Status and Water Chemistry

Picnic had an average total phosphorus concentration of 8 µg/L and an average total nitrogen concentration of 137 µg/L. Total chlorophyll *a* concentrations averaged 1 µg/L and the water clarity as measured by use of a Secchi disc averaged 2.6 m (Table 2). The lake had an average pH of 4.3 and an average total alkalinity of 0 mg/L as $CaCO_3$. The average specific conductance was 69 µS/cm @ 25 C and the average water color was 0 Pt-Co units. The adjusted chlorophyll *a* value in Picnic was 2 µg/L. Using this value and the classification system of Forsberg and Ryding (1980), Picnic was classified as an oligotrophic lake during this study.

Aquatic Plants

Picnic had a low abundance of aquatic macrophytes with a percent area coverage (PAC) and percent volume infested (PVI) with aquatic macrophytes of 86% and 5%, respectively (Table 3). The average above-ground biomass of emergent, floating-leaved and submersed vegetation was 0.8, 0.7 and 0.2 kg wet wt/m^2, respectively (Table 3). The average epiphytic algal concentration associated with the aquatic macrophytes was 19.2 mg chlorophyll *a*/cm^2 of host plant and 34.9 mg chlorophyll *a*/kg wet wt of host plant (Table 3). Fifteen species of aquatic macrophytes were collected in Picnic. The most commonly encountered plant species were *Nuphar luteum, Bacopa caroliniana,* and *Leersia hexandra,* which occurred in 90%, 90%, and 80% of the transects, respectively (Table 238).

No previous vegetation studies have been conducted on Picnic, but Picnic is a private lake on undeveloped land. The owner (Mr. Jack Williams of Gainesville, Florida) and his land caretaker agree the lake's vegetation and general appearance has remained the same for several years prior to our sampling. Thus, the fish population in Picnic can be considered the product of an oligotrophic lake with low to moderate levels of aquatic vegetation.

Invertebrates

The average number and biomass of epiphytic macroinvertebrates in Picnic was 188 individuals/kg wet wt of host plant and 0.32 g wet wt/kg wet wt of host plant (Table 5). Average number and biomass of benthic macroinvertebrates in Picnic, as estimated with a ponar dredge, was 93 individuals/m^2 and 0.42 g wet wt/m^2, respectively (Table 5). The zooplankton population in Picnic was dominated by nauplii and copepods with 52,100 and 28,300 individuals/m^3, respectively (Table 5).

Table 238. Occurrence of plant species in ten evenly-spaced transects around Lake Picnic.

Common name	Scientific name	Percent of Transects
slender spikerush	*Eleocharis baldwinii*	50
banana-lily	*Nymphoides aquatica*	30
spatterdock	*Nuphar luteum*	90
pickerelweed	*Pontederia cordata*	30
lemon bacopa	*Bacopa caroliniana*	90
water-pennywort	*Hydrocotyle umbellata*	60
purple bladderwort	*Utricularia purpurea*	20
bog-moss	*Mayaca fluviatilis*	50
buttonbush	*Cephalanthus occidentalis*	10
maidencane	*Panicum hemitomon*	80
	Fuirena sciropoidea	80
	Leersia hexandra	90
	Utricularia floridana	20
St. John's wort	*Hypericum* spp.	80
yellow-eyed grass	*Xyris* spp.	20

<u>Fish</u>

Eleven species of fish were collected from Picnic (Table 239, 240 and 241). The most abundant species collected with rotenone sampling were warmouth and lake chubsucker. These species had average standing stocks in littoral blocknets of 1,500 and 750 fish/ha, respectively (Table 239). The most abundant open-water species collected in the experimental gillnets were bluegill and largemouth bass with 17 and 1.3 fish/net/24 hr, respectively (Table 240). The most abundant species collected using electrofishing were lake chubsucker and bluegill with catch per unit efforts of 214 and 32.4 fish per hour, respectively (Table 241). Average first-year growth of bluegill and largemouth bass was 47 and 137 mm TL, respectively (Table 6). Mark-recapture estimates indicated that there were 44 harvestable bluegill and 6 harvestable largemouth bass per hectare in Picnic Lake (Table 7).

The fish population of Picnic was examined with electrofishing by the Florida Game and Fresh Water Fish Commission in 1986 (McKinney unpublished data). Six species were collected for a total of 80 kg/hr. **(Text continued on page 487)**

Table 239. Blocknet-rotenone estimates of total and harvestable fish stock (number/hectare) and standing crop (kg/hectare) for Picnic. Mean values for littoral and open-water nets are listed by species with the corresponding standard error of the mean.

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Littoral nets (n=2) for total fish				
Lake chubsucker	753	506	20.0	11.07
Golden topminnow	43	31	0.1	0.03
Lined topminnow	173	148	0.2	0.16
Mosquitofish	25	0	0.0	0.00
Brook silverside	0	0	0.0	0.00
Everglades pygmy sunfish	6	6	0.0	0.00
Bluespotted sunfish	124	12	0.2	0.01
Warmouth	1538	525	11.0	1.54
Bluegill	371	62	12.8	6.71
Largemouth bass	80	31	6.7	1.02
Swamp darter	12	0	0.0	0.00
Total	3125		50.8	
Open-water nets (n=2) for total fish				
Lake chubsucker	25	25	4.6	4.57
Golden topminnow	0	0	0.0	0.00
Lined topminnow	0	0	0.0	0.00
Mosquitofish	0	0	0.0	0.00
Brook silverside	6	6	0.0	0.01
Everglades pygmy sunfish	0	0	0.0	0.00
Bluespotted sunfish	0	0	0.0	0.00
Warmouth	0	0	0.0	0.00
Bluegill	142	105	9.8	7.20
Largemouth bass	62	62	8.0	8.02
Swamp darter	19	19	0.0	0.01
Total	253		22.4	

Table 239. (Concluded)

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Littoral nets (n=2) for harvestable fish				
Warmouth	19	6.2	1.6	0.92
Bluegill	93	67.9	6.8	5.30
Largemouth bass	25	0.0	3.8	0.38
Total	136		12.2	
Open-water nets (n=2) for harvestable fish				
Warmouth	0	0.0	0.0	0.00
Bluegill	111	74.1	8.4	5.80
Largemouth bass	25	24.7	3.9	3.86
Total	136		12.3	

Table 240. Experimental gillnet (five 10-meter long sections of 1.9, 2.5, 3.8, 5.1, and 6.4 cm bar mesh, which were 2.4 meter deep) catch per unit effort estimates of total and harvestable fish number (number/net/24 hr) and weight (kg/net/24 hr) for Picnic. Mean values for experimental gillnets are listed by species with the corresponding standard error of the mean.

Common Name	Fish number (number/net/24 hr)	Standard Error	Fish weight (kg/net/24 hr)	Standard Error
Gillnets (n=3) for total fish				
Lake chubsucker	1.3	1.33	0.3	0.27
Bluegill	17.0	8.08	0.6	0.27
Largemouth bass	1.3	1.33	0.2	0.15
Total	19.67		1.07	
Gillnets (n=3) for harvestable fish				
Bluegill	2.3	1.86	0.1	0.10
Largemouth bass	0.0	0.00	0.0	0.00
Total	2.3		0.1	

Table 241. Electrofishing catch per unit effort estimates of total and harvestable fish number (number/hr) and weight (kg/hr) for Picnic. Mean values are listed by species with the corresponding standard error of the mean.

Common Name	Number (number/hr)	Standard Error	Weight (kg/hr)	Standard Error
Electrofishing runs (n=5) for total fish				
Lake chubsucker	213.6	43.91	115.70	2.45
Lined topminnow	1.2	1.20	0.02	0.00
Brook silverside	2.4	1.47	0.02	0.00
Warmouth	9.6	8.18	2.72	0.27
Bluegill	32.4	11.94	9.22	0.35
Largemouth bass	12.0	4.65	20.12	1.30
Total	271.2		147.82	
Electrofishing runs (n=5) for harvestable fish				
Warmouth	0.0	0.00	0.00	0.00
Bluegill	6.0	2.68	0.39	0.18
Largemouth bass	4.8	3.50	1.55	1.24
Total	10.8		1.94	

The same six species were captured by use of electrofishing in this study (Table 241), but we had a higher catch per unit effort of 148 kg/hr. This was because of the large number of lake chubsuckers that were collected in 1989 (Table 241), but not 1986. Thus, the fish population seems to have remained stable over the last couple years.

Swim Pond

Location and Morphology

Swim Pond is located in Marion County, Florida (Latitude 29.10 N; Longitude 81.49 W). The lake lies in the St. Johns Offset division of the Central Lake District (Brooks 1981). The geology is dominated by deeply weathered clayey sand and clayey sands of the Hawthorne Formation. Swim Pond was sampled from 1989 to 1990 and had a surface area, shoreline length, and mean depth of 9 ha, 1.94 km and 0.6 m, respectively (Table 1).

Trophic Status and Water Chemistry

Swim Pond had an average total phosphorus concentration of 25 µg/L and an average total nitrogen concentration of 1025 µg/L. Total chlorophyll *a* concentrations averaged 11 µg/L and the water clarity as measured by use of a Secchi disc averaged 0.6 m (Table 2). The lake had an average pH of 5.6 and an average total alkalinity of 0.9 mg/L as $CaCO_3$. The average specific conductance was 43 µS/cm @ 25 C and the average water color was 26 Pt-Co units. The adjusted chlorophyll *a* value for Swim Pond was 118 µg/L. Using this value and the classification system of Forsberg and Ryding (1980), Swim Pond was classified as an hypereutrophic lake.

Aquatic Plants

Swim Pond had a high abundance of aquatic macrophytes with a percent area coverage (PAC) and percent volume infested (PVI) with aquatic macrophytes of 87% and 78%, respectively (Table 3). The average above-ground biomass of emergent, floating-leaved and submersed vegetation was 1.2, 0.9, and 0.4 kg wet wt/m^2, respectively (Table 3). The average epiphytic algal concentration associated with the aquatic macrophytes was 29.1 mg chlorophyll *a*/cm^2 of host plant and 74.7 mg chlorophyll *a*/kg wet wt of host plant (Table 3). Nineteen species of aquatic macrophytes were collected in Swim Pond (Table 242). The most common encountered plant species were *Utricularia floridana, Panicum hemitomon* and *Brasenia schreberi*, which occurred in 100%, 90% and 80% of the transects, respectively .

The plant community of Swim Pond was sampled by the University of Florida in 1985 (Canfield and Joyce 1985). Aquatic macrophytes covered 100% of the lake bottom. The

Table 242. Occurrence of plant species in ten evenly-spaced transects around Swim Pond.

Common name	Scientific name	Percent of Transects
slender spikerush	*Eleocharis baldwinii*	50
banana-lily	*Nymphoides aquatica*	50
water-shield	*Brasenia schreberi*	80
spatterdock	*Nuphar luteum*	50
fragrant water-lily	*Nymphaea odorata*	20
red ludwigia	*Ludwigia repens*	30
lemon bacopa	*Bacopa caroliniana*	50
water-pennywort	*Hydrocotyle umbellata*	50
variable-leaf milfoil	*Myriophyllum heterophyllum*	70
cone-spur bladderwort	*Utricularia gibba*	10
purple bladderwort	*Utricularia purpurea*	50
maidencane	*Panicum hemitomon*	90
	Fuirena sciropoidea	70
	Leersia hexandra	50
	Utricularia floridana	100
St. John's wort	*Hypericum* spp.	10
	Rhynchospora inundata	20
yellow-eyed grass	*Xyris spp.*	20
	Eleocharis elongata	60

dominant aquatic macrophytes in the lake were *Utricularia floridana* and *U. purpurea*. These plants covered over 80% of the surface area, which is similar to our findings in 1989 (Table 3 and 242). Thus, the fish population in Swim Pond can be considered the product of a hypereutrophic lake with high levels of aquatic vegetation.

Invertebrates

The average number and biomass of epiphytic macroinvertebrates in Swim Pond was 268 individuals/kg wet wt of host plant and 0.56 g wet wt/kg wet wt of host plant (Table 5). Average number and biomass of benthic macroinvertebrates in Swim Pond, as estimated with a ponar dredge, was 53 individuals/m^2 and 0.08 g wet wt/m^2, respectively (Table 5). The zooplankton population in Swim Pond was dominated by rotifers and nauplii with 128,000 and 40,400 individuals/m^3, respectively (Table 5).

Fish

Fifteen species of fish were collected from Swim Pond (Table 243, 244 and 245). The most abundant species collected with rotenone sampling were dollar sunfish and warmouth. These species had average standing stocks in littoral blocknets of 4,900 and 3,200 fish/ha, respectively (Table 243). The most abundant open-water species collected in the experimental gillnets were lake chubsucker and golden shiner with 4.5 and 3.5 fish/net/24 hr, respectively (Table 244). The most abundant species collected using electrofishing were bluegill and lake chubsucker with catch per unit efforts of 81 and 54 fish per hour, respectively (Table 245). Average first-year growth of bluegill, redear sunfish and largemouth bass was 76, 82, and 162 mm TL, respectively (Table 6). No previous data on the fish population in Swim Pond were available. **(Text continued on page 495)**

Table 243. Blocknet-rotenone estimates of total and harvestable fish stock (number/hectare) and standing crop (kg/hectare) for Swim Pond. Mean values for littoral and open-water nets are listed by species with the corresponding standard error of the mean.

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Littoral nets (n=2) for total fish				
Golden shiner	86	12	1.3	1.11
Lake chubsucker	93	68	14.0	10.05
Brown bullhead	6	6	1.5	1.45
Golden topminnow	1217	895	1.5	1.13
Lined topminnow	914	642	0.6	0.54
Mosquitofish	463	463	0.2	0.17
Least killifish	117	105	0.0	0.01
Pygmy killifish	62	62	0.0	0.01
Warmouth	3205	1105	19.9	4.19
Bluegill	1501	784	8.0	3.83
Dollar sunfish	4915	4693	6.9	6.58
Redear sunfish	167	68	0.9	0.62
Largemouth bass	68	19	5.9	2.28
Swamp darter	49	49	0.0	0.02
Total	12862		60.8	
Littoral nets (n=2) for harvestable fish				
Brown bullhead	6	6.2	1.5	1.45
Warmouth	12	0.0	1.3	0.00
Bluegill	6	6.2	0.5	0.49
Dollar sunfish	0	0.0	0.0	0.00
Redear sunfish	0	0.0	0.0	0.00
Largemouth bass	0	0.0	0.0	0.00
Total	25		3.2	

Table 243. (Concluded)

Common Name	Stock (number/ha)	Standard Error	Standing Crop (kg/ha)	Standard Error
Open-water nets (n=1) for total fish				
Golden shiner	86	0	4.3	0.00
Lake chubsucker	25	0	6.7	0.00
Brown bullhead	0	0	0.0	0.00
Golden topminnow	0	0	0.0	0.00
Lined topminnow	12	0	0.0	0.00
Mosquitofish	0	0	0.0	0.00
Least killifish	0	0	0.0	0.00
Pygmy killifish	0	0	0.0	0.00
Warmouth	259	0	2.2	0.00
Bluegill	655	0	14.4	0.00
Dollar sunfish	198	0	0.3	0.00
Redear sunfish	99	0	4.3	0.00
Largemouth bass	86	0	15.5	0.00
Swamp darter	0	0	0.0	0.00
Total	1420		47.6	
Open-water nets (n=1) for harvestable fish				
Brown bullhead	0	0.0	0.0	0.00
Warmouth	0	0.0	0.0	0.00
Bluegill	99	0.0	10.6	0.00
Dollar sunfish	0	0.0	0.0	0.00
Redear sunfish	25	0.0	2.5	0.00
Largemouth bass	37	0.0	12.5	0.00
Total	161		25.6	

Table 244. Experimental gillnet (five 10-meter long sections of 1.9, 2.5, 3.8, 5.1, and 6.4 cm bar mesh, which were 2.4 meter deep) catch per unit effort estimates of total and harvestable fish number (number/net/24 hr) and weight (kg/net/24 hr) for Swim Pond. Mean values for experimental gillnets are listed by species with the corresponding standard error of the mean.

Common Name	Fish number (number/net/24 hr)	Standard Error	Fish weight (kg/net/24 hr)	Standard Error
Gillnets (n=2) for total fish				
Golden shiner	3.5	2.50	0.3	0.23
Lake chubsucker	4.5	0.50	1.2	0.32
Brown bullhead	0.5	0.50	0.1	0.14
Warmouth	1.0	0.00	0.0	0.00
Bluegill	2.5	2.50	0.2	0.17
Largemouth bass	2.5	1.50	0.3	0.19
Total	14.50		2.15	
Gillnets (n=2) for harvestable fish				
Brown bullhead	0.5	0.50	0.1	0.14
Warmouth	0.0	0.00	0.0	0.00
Bluegill	1.5	1.50	0.1	0.12
Largemouth bass	1.0	1.00	0.1	0.15
Total	3.0		0.4	

Table 245. Electrofishing catch per unit effort estimates of total and harvestable fish number (number/hr) and weight (kg/hr) for Swim Pond. Mean values are listed by species with the corresponding standard error of the mean.

Common Name	Number (number/hr)	Standard Error	Weight (kg/hr)	Standard Error
Electrofishing runs (n=2) for total fish				
Lake chubsucker	54.0	6.00	93.0	1.28
Lined topminnow	15.0	9.00	0.10	0.00
Brook silverside	3.0	3.00	0.0	0.00
Warmouth	15.0	15.00	1.5	0.15
Bluegill	81.0	39.00	6.5	0.17
Redear sunfish	3.0	3.00	1.1	0.11
Largemouth bass	27.0	3.00	32.7	0.44
Total	198.0		134.9	
Electrofishing runs (n=2) for harvestable fish				
Warmouth	0.0	0.00	0.0	0.00
Bluegill	0.0	0.00	0.0	0.00
Redear sunfish	0.0	0.00	0.0	0.00
Largemouth bass	9.0	3.00	2.1	0.87
Total	9.0		2.1	

Influence of Aquatic Macrophytes on Algal Biomass, Water Transparency and Lake Trophic State Classifications

Aquatic macrophytes can influence a variety of biogeochemical cycles in lakes (Wetzel 1983; Carpenter and Lodge 1986). Consequently, concerns are often raised regarding possible adverse impacts on water quality when aquatic plant management programs are proposed for individual water bodies. In Florida, the management of macrophytes is often opposed because there is concern that the loss of macrophytes will stimulate excessive growths of phytoplankton. This concern is based on studies that have shown that aquatic macrophytes, especially submersed macrophytes, can inhibit the development of phytoplankton (Hasler and Jones 1949; Hogetsu et al. 1960; Carter and Hestand 1977; Carpenter and Lodge 1986) and practical experiences in Florida where the removal of aquatic macrophytes has greatly enhanced the growth of phytoplankton and reduced water clarity (Canfield et al. 1983b). In recent years, it has even been advocated that aquatic macrophytes should be planted along the shoreline to improve water quality and some Florida cities have passed ordinances supporting revegetation of shorelines.

Studies of lakes located outside of Florida have demonstrated: 1) there are strong positive correlations between total phosphorus and nitrogen concentrations and algal biomass as estimated by chlorophyll *a* concentrations (Sakamoto 1966; Jones and Bachmann 1976; Hoyer and Jones 1983) and 2) there are strong inverse relations between water clarity as measured with a Secchi disk and algal densities, inorganic suspended solids and color (Bachmann and Jones 1974; Jones and Bachmann 1978; Hoyer and Jones 1983). Similar relationships (Table 246) have also been established for Florida lakes (Canfield 1983; Canfield and Hodgson 1983), but prior to the study of Canfield et al. (1984), there was no quantitative information on how different levels of macrophyte abundance influence algal biomass and water transparency in lakes.

Canfield et al. (1984) used data from 32 Florida lakes having a wide range of limnological conditions to demonstrate that algal biomass, as measured by chlorophyll *a* concentrations, increased as the percentage of the lake's total volume infested with aquatic macrophytes (PVI) decreased. They also presented an empirical model to provide a quantitative basis for assessing the potential impact of different levels of macrophyte

Table 246. Comparison of published empirical models for Florida lakes and models developed with data collected for this study from 60 Florida lakes between 1986 and 1990.

Source	Equation	Model
Canfield (1983)	8	log 10 (chlorophyll *a*) = - 2.49 + 0.27 log 10 (total phosphorus) + 1.06 log 10 (total nitrogen) $R^2 = 0.79$
This Study	9	log 10 (chlorophyll *a*) = - 1.52 + 0.68 log 10 (total phosphorus) + 0.58 log 10 (total nitrogen) $R^2 = 0.81$
Canfield and Hodgson (1983)	10	log (Secchi) = 2.01 - 0.37 log (chlorophyll *a*) - 0.28 log (color) $R^2 = 0.78$
This Study	11	log (Secchi) = 1.74 - 0.39 log (chlorophyll *a*) - 0.17 log (color) $R^2 = 0.80$
Canfield et al. (1984)	12	log 10 (chlorophyll *a*) = - 2.08 + 1.02 log 10 (total nitrogen) + 0.28 log 10 (total phosphorus) - 0.005 PVI $R^2 = 0.86$
This Study	13	log 10 (chlorophyll *a*) = - 1.80 + 0.77 log 10 (total nitrogen) + 0.55 log 10 (total phosphorus) - 0.003 PVI $R^2 = 0.83$

abundance on chlorophyll yields in lakes (Table 246; Equation 12). Their model suggested that large amounts of aquatic macrophytes are needed in a lake before substantial reductions in algal biomass will occur and that a fringe of aquatic macrophytes has very limited potential to reduce whole-lake phytoplankton biomass. Canfield et al. (1984), however, noted that their sampling of lakes was limited and that further testing was needed to ascertain the applicability of their results to other Florida lakes.

An objective of our study was to determine if the model presented by Canfield et al. (1984) was valid for a wider range of Florida lakes. We found that the percentage of a lake's volume occupied with macrophytes (Canfield et al.'s PVI term) had a significant negative effect on chlorophyll *a* concentrations and we were able to develop an empirical model (Table 246; Equation 13) that is very similar to the model proposed by Canfield et al. (1984). This finding strongly suggests that Canfield et al.'s approach for quantitatively assessing the effects of macrophytes on algal biomass in Florida lakes is valid for many Florida lakes. The regression coefficient for PVI, however, remains small (coefficient = -0.003) relative to the regression coefficients for phosphorus and nitrogen (Table 246; Equation 13). This indicates that phosphorus and nitrogen concentrations are the primary determinants of chlorophyll *a* concentrations in open-water and that vegetation does not have a significant effect on whole-lake chlorophyll *a* concentrations until high levels of vegetation occur.

We suggest that the areal coverage of aquatic macrophytes on a percentage basis (PAC) will have to be between 30% and 50% before there is a chance to statistically detect a major effect of macrophytes on whole-lake chlorophyll *a* concentrations. For example, we used Equation 13 to predict chlorophyll *a* concentrations for five hypothetical combinations of total phosphorus and total nitrogen concentrations (assuming phosphorus limitation and TN:TP = 20:1) given PVI values ranging from 0% to 100% (Table 247). Knowlton et al. (1984) reported that the temporal variation in chlorophyll *a* values in lakes ranges naturally about $\pm$ 30% of the mean value. Significant changes in chlorophyll concentrations for our five hypothetical lakes, therefore, would not be detected using the criteria of Knowlton et al. (1984) until PVI values exceed approximately 40%. The modeling efforts also suggest that large amounts of aquatic macrophytes are needed in a lake before substantial reductions in algal biomass will occur and that a fringe of aquatic macrophytes has very limited potential to reduce whole-lake phytoplankton biomass.

Table 247. Chlorophyll *a* concentrations (µg/L) predicted by use of Equation 6 for five hypothetical cases that depict different combinations of total phosphorus (TP) and total nitrogen (TN) concentrations (µg/L) and percent of the lake volume infested with macrophytes (PVI). Values in parentheses are Secchi disc transparencies (m) predicted using the global Secchi-chlorophyll relationship of Jones and Bachmann (1978).

	Hypothetical Case				
PVI (%)	1 (TP = 10, TN = 200)	2 (TP = 20, TN = 400)	3 (TP = 40, TN = 800)	4 (TP = 80, TN = 1600)	5 (TP = 160, TN = 3200)
0	3.3 (3.3)	8.3 (2.0)	21 (1.2)	52 (0.73)	129 (0.44)
10	3.1 (3.4)	7.8 (2.1)	19 (1.3)	48 (0.76)	121 (0.46)
20	2.9 (3.6)	7.2 (2.2)	18 (1.3)	45 (0.79)	113 (0.48)
30	2.7 (3.7)	6.8 (2.2)	17 (1.4)	42 (0.82)	105 (0.50)
40	2.5 (3.8)	6.3 (2.3)	16 (1.4)	39 (0.85)	98 (0.52)
50	2.4 (4.0)	5.9 (2.4)	15 (1.5)	37 (0.89)	92 (0.54)
60	2.2 (4.1)	5.5 (2.5)	14 (1.5)	34 (0.92)	85 (0.56)
70	2.1 (4.3)	5.1 (2.6)	13 (1.6)	32 (0.96)	80 (0.58)
80	1.9 (4.5)	4.8 (2.7)	12 (1.6)	30 (0.99)	74 (0.60)
90	1.8 (4.6)	4.5 (2.8)	11 (1.7)	28 (1.03)	69 (0.63)
100	1.7 (4.8)	4.2 (2.9)	10 (1.8)	26 (1.07)	65 (0.65)

To confirm the results of our modeling efforts, we examined long-term changes in chlorophyll *a* concentrations at three lakes where grass carp were used to totally remove aquatic macrophytes (Figure 2, 3 and 4). At Lake Baldwin, Secchi transparencies were greater than 5 m, total phosphorus concentrations averaged 11 μg/L and chlorophyll *a* concentrations were less than 3 μg/L when abundant growths of hydrilla covered 80% of the lake's bottom (Figure 2). For these conditions, the lake would have been classified as oligotrophic using the criteria (Table 248) of Forsberg and Ryding (1980). The abundance of aquatic macrophytes, however, clearly demonstrated that the lake was productive or eutrophic. After the loss of aquatic macrophytes resulted in a functional and structural shift to phytoplankton, Secchi transparencies decreased to less than 2 m, total phosphorus concentrations averaged over 20 μg/L and chlorophyll *a* concentration averaged over 10 μg/L. These major changes in water quality, however, occurred before the abundance of aquatic macrophytes was reduced below 50% areal coverage. Similar major changes in water quality also occurred at Lake Pearl (Figure 3) and Lake Wales (Figure 4) when macrophyte coverage was still at levels considered by some to be a "weed" problem.

Table 248. General criteria for classifying lakes into different trophic state categories (Forsberg and Ryding 1980).

Trophic State	Total Nitrogen (μg/L)	Total Phosphorus (μg/L)	Chlorophyll *a* (μg/L)	Secchi (m)
Oligotrophic	< 400	< 15	< 3	> 4
Mesotrophic	400-600	15-25	3-7	2.5-4
Eutrophic	600-1500	25-100	7-40	1-2.5
Hypereutrophic	>1500	>100	>40	<1

We are not certain what the causative mechanisms are for the inverse relation between aquatic macrophytes and chlorophyll *a* concentrations. There is a significant hyperbolic relation between PAC and PVI (Figure 5). Once the areal coverage of aquatic macrophytes

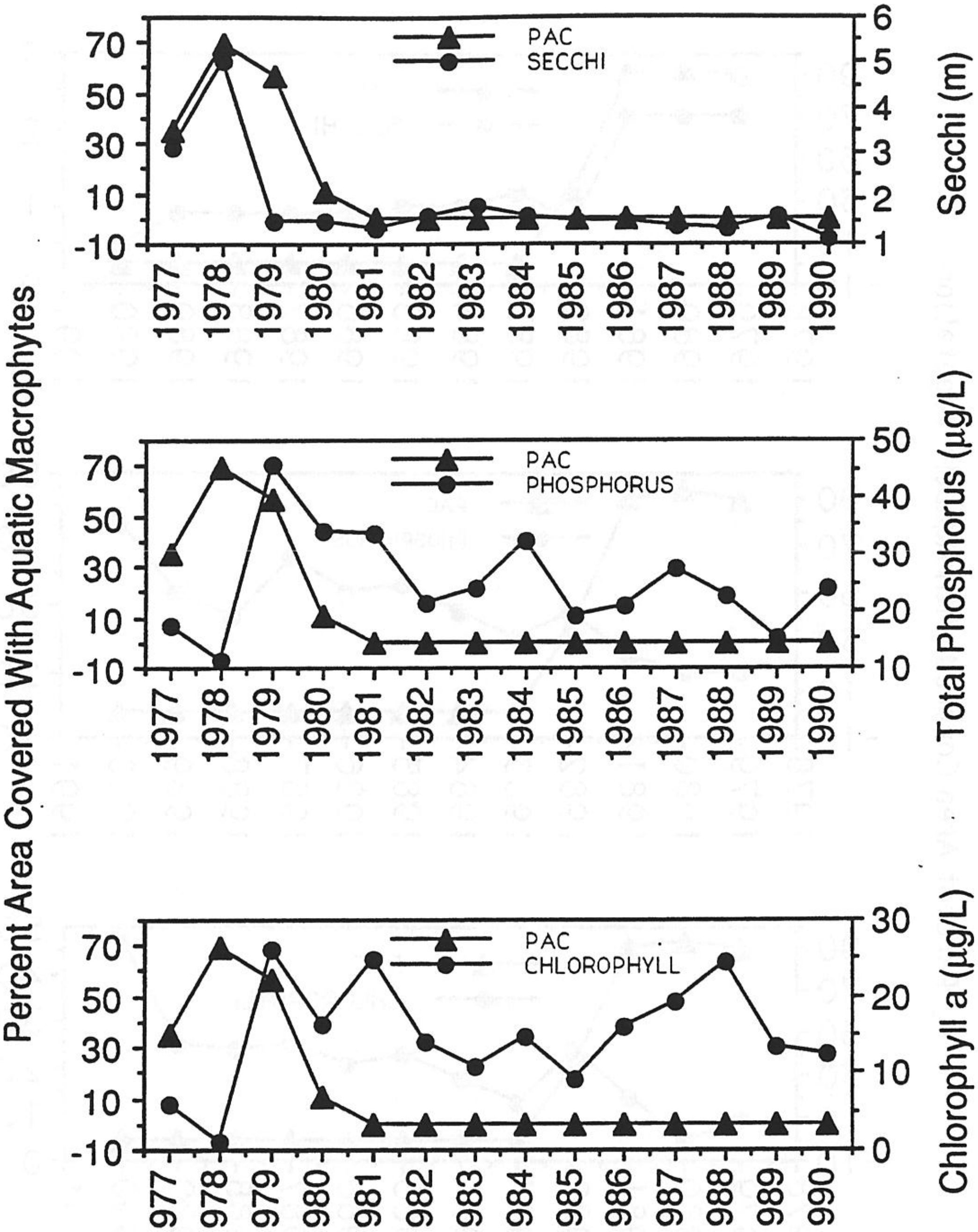

Figure 2. Changes in trophic state parameters of Lake Baldwin 1977 to 1990, after removal of vegetation by 1980 with grass carp.

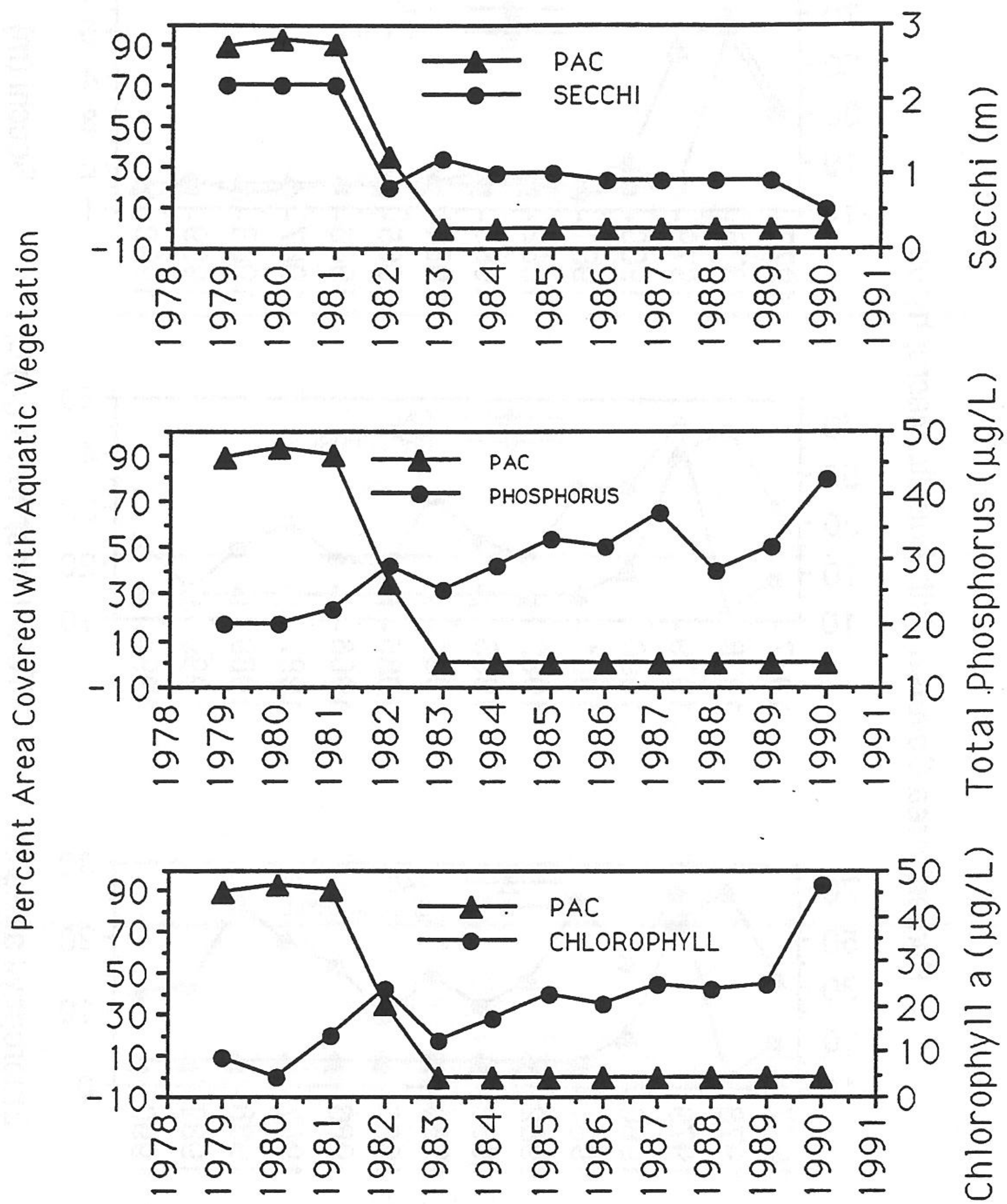

Figure 3. Changes in trophic state parameters of Lake Pearl 1979 to 1990, after removal of vegetation by 1983 with grass carp.

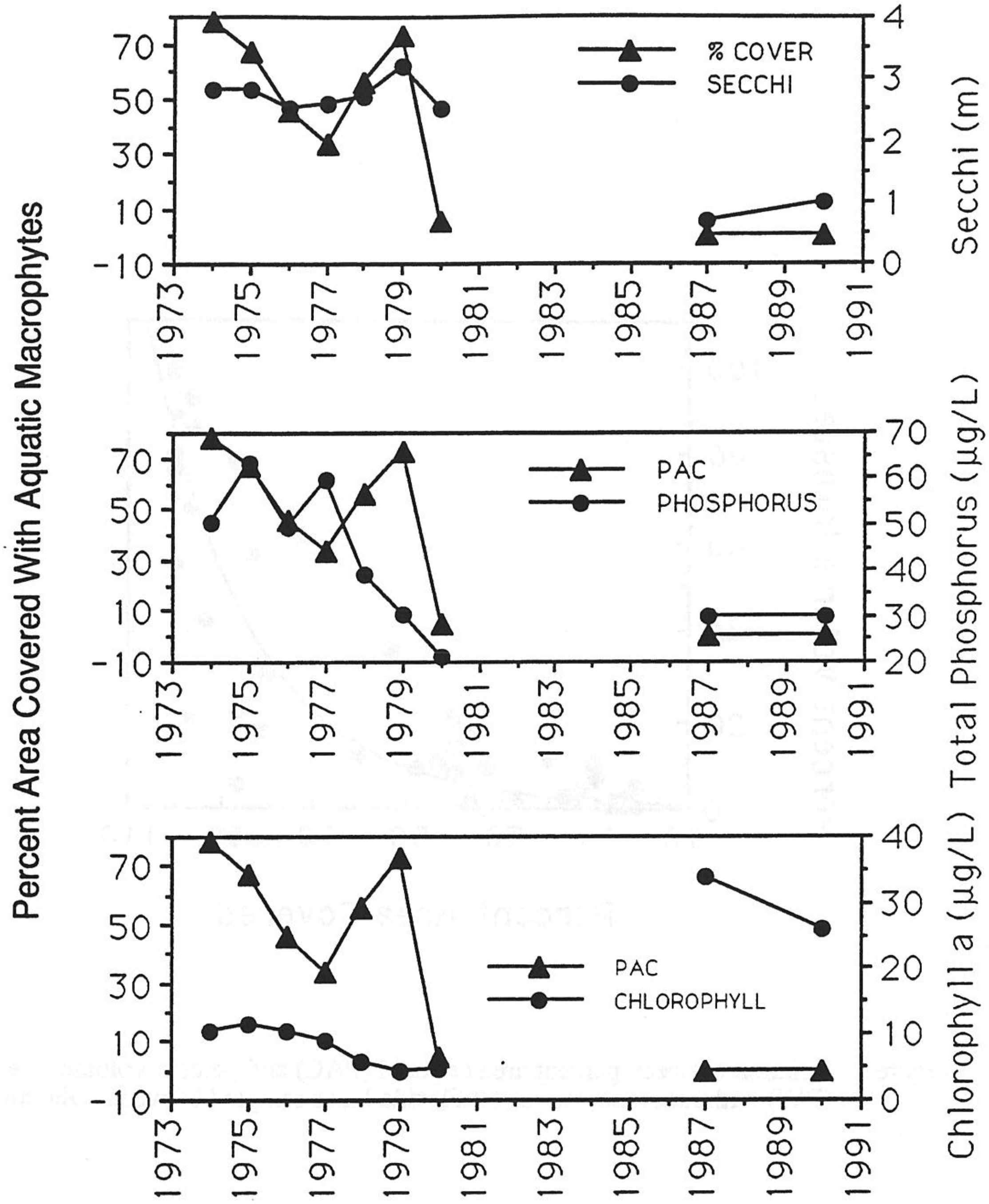

Figure 4. Changes in trophic state parameters of Lake Wales 1974 to 1990, after total removal of vegetation by 1980 with grass carp.

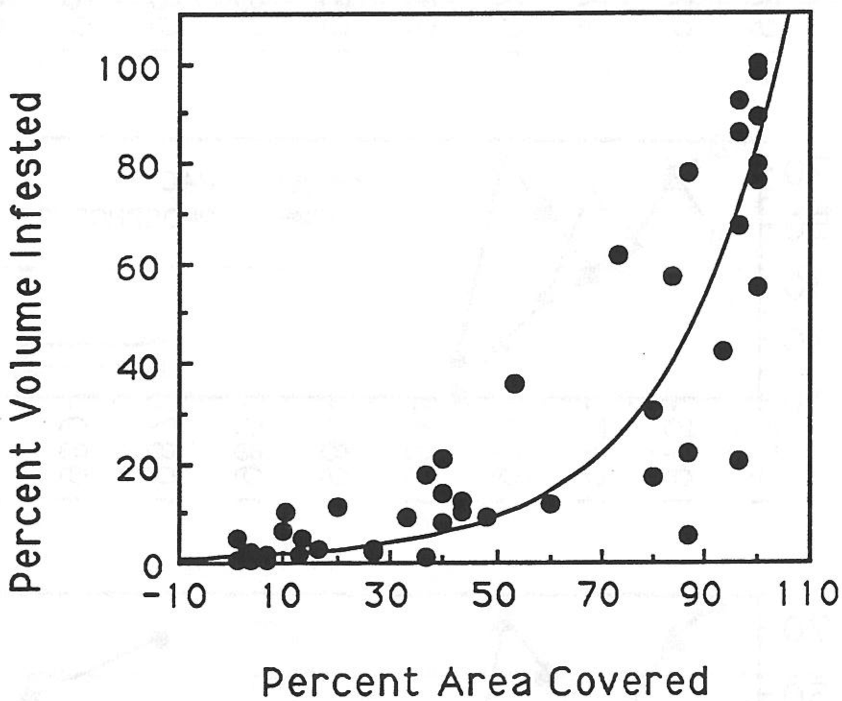

Figure 5. Relation between percent area covered (PAC) and percent volume infested (PVI) with macrophytes for 60 Florida lakes sampled between 1986 and 1990.

exceeds 30%, there is a strong probability that there will be a significant increase in PVI and macrophyte biomass. Several factors are probably involved in reducing algal biomass both separately and in combination including: 1) competition for nutrients by macrophytes and their associated periphyton; 2) a reduction in nutrient cycling because macrophytes reduce wind mixing and the resuspension of nutrients from bottom sediments; and 3) increased sedimentation of planktonic algae due to a reduction in water turbulence by macrophytes.

Whatever the mechanisms are for reducing algal biomass, our modeling efforts and whole-lake experiments with macrophyte removal clearly show that a fringe of macrophytes around the edge of a lake will not significantly reduce whole-lake algal biomass and improve whole-lake water clarity in a Florida lake. Our results also suggest that managing aquatic macrophytes at a low level will have virtually no effect on whole-lake algal biomass. Thus, from a practical standpoint "maintenance control" of aquatic macrophytes would be the best approach to minimize noticeable changes in water quality. If aquatic plant management programs, however, are initiated on lakes having large amounts of aquatic macrophytes, the public must be informed that there will be greater growths of phytoplankton and that the water will be less clear. While a fringe of aquatic macrophytes in a lake may have some benefits for wildlife and reduced erosion of terrestrial lands, there is no scientific justification for programs that require the planting of aquatic macrophytes or the maintenance of aquatic macrophytes in near-shore waters to improve whole-lake water quality if water quality is defined only in terms of whole-lake chlorophyll *a* concentrations and water clarity as measured by a Secchi disc.

An additional consideration for the management of aquatic macrophytes is the distribution of aquatic macrophytes abundances in lakes having different trophic states. For example, the hypereutrophic lakes in our study either had PVI values greater than 75% or less than 25% (Figure 6). This strongly suggests that any attempts at managing macrophytic vegetation in these types of lakes at median levels, a goal of many aquatic plant management programs, is going to be very difficult. There is also a strong possibility that all submersed vegetation could be lost because of excessive growths of phytoplankton. PVI values for eutrophic lakes, however, range from 0 to nearly 100%; thus these types of lakes seem to be the best candidates for managing vegetation at moderate levels. Oligotrophic and mesotrophic lakes, however only have the potential of reaching PVI value

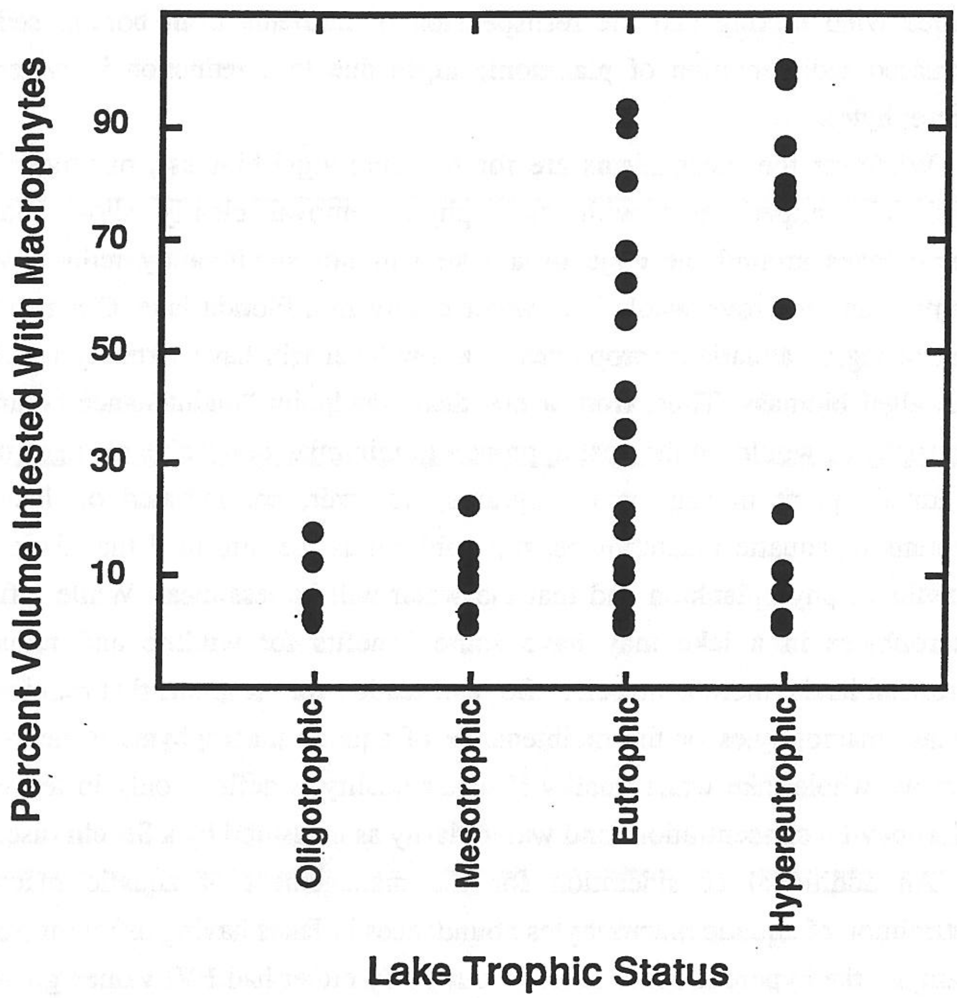

Figure 6. The relation between lake trophic status and percent volume infested with aquatic macrophytes, for 60 Florida lakes

of 25%. It is therefore very important for those individuals charged with developing aquatic plant management programs for individual lakes to accurately assess the trophic status of lakes.

Determining a lake's trophic status is a critical step in the development of of not only aquatic plant management programs, but environmentally-sound lake management programs (Olem and Flock 1990). Consequently, an objective trophic state classification system for lakes has long been sought by limnologists and fisheries biologists to rank and compare lakes with different structural and functional characteristics (Naumann 1919, 1932; Thienemann 1921; Birge and Juday 1927). During the 1970s and 1980s, numerous quantitative trophic classification systems were developed to characterize lakes and to predict their future conditions given various anthropogenic activities (Likens 1975; Carlson 1977, 1979; Walker 1979; Forsberg and Ryding 1980; Kratzer and Brezonik 1981). The Carlson Trophic State Index (Carlson 1977, 1979) and the trophic state classification system of Kratzer and Brezonik (1981) are now routinely used by many local and state agencies in Florida to rank the trophic status of lakes. These trophic classification systems have several purported advantages including minimal data requirements, sensitivity in ranking trophic status, and ease of interpretation. These classification systems, however, use only the classical trophic state indicators of open-water nutrient concentrations, algal biomass, and water transparency (Table 248). They give no consideration to aquatic macrophytes even though these plants are an important biological component of many lakes (Wetzel 1964; Wetzel and Hough 1973).

Canfield et al. (1983a) suggested that errors in trophic state assessment will be small in lakes where macrophytes are confined to small littoral areas, but that large errors could result in macrophyte-dominated lakes. This occurs because nutrient and chlorophyll concentrations can be low and Secchi disc transparency can be high in waters where there is an abundance of macrophytes. They proposed that the trophic status of lakes having growths of aquatic macrophytes could be assessed by adding the phosphorus in the macrophytes to the phosphorus in the water and then using the potential water column phosphorus concentration to classify the lake's trophic status.

The trophic state assessment method of Canfield et al. (1983a) is consistent with Hutchinson's suggestion that trophic state determinations should be based on the total potential concentration of nutrients in a lake and the general belief that phosphorus is the nutrient generally limiting the productivity of lakes. The method, however, has serious limitations if it is to be applied to all Florida lakes. A major problem with the method is that phosphorus is not always the limiting nutrient. There are many Florida lakes where nitrogen is the primary limiting nutrient (Canfield 1981; Canfield 1983; Canfield and Hoyer 1988a). For example, we assessed the trophic status of the 60 study lakes based on our qualitative assessment of each lake's overall biological productivity, the primary determinant of lake trophic status. We then compared our trophic assessments with those obtained by use of the method proposed by Canfield et al. (1983a). The trophic classifications based on phosphorus differed for 26 lakes. When we used nitrogen, only 19 lakes had discrepant classifications, a reduction of misclassifications from 43% to 32%.

Although we had fewer misclassification when we used nitrogen, nitrogen is not always the limiting nutrient (Canfield and Hoyer 1989). We, therefore, decided to modify the methods of Canfield et al. (1983a) in an effort to better assess the trophic status of the lakes sampled in this study. Because chlorophyll *a* can be used as an index of lake productivity, we calculated an adjusted chlorophyll *a* concentration for each lake. The adjusted chlorophyll *a* concentrations were calculated using the potential water column phosphorus and nitrogen concentrations (adding the nutrients associated with the aquatic macrophyte community to the nutrients in the lake's water column and dividing by the lake's volume) and the chlorophyll *a* - total phosphorus-total nitrogen relationship (Table 246; Equation 8) of Canfield (1983). The adjusted chlorophyll *a* values were then used with the trophic classification system (Table 248) of Forsberg and Ryding (1980) to assess the trophic status of our study lakes. The trophic classifications using the adjusted chlorophyll *a* values and the classification system of Forsberg and Ryding (1980) agreed with our subjective classifications in all but 18% (11) of the lakes. Thus, we feel that the use of adjusted chlorophyll *a* values can provide a better assessment of lake trophic status than either phosphorus or nitrogen water column values for lakes with large populations of aquatic macrophytes.

Examining the relationship between measured and adjusted chlorophyll *a* concentrations shows that as the percent area covered (PAC) with macrophytes increases, the measured chlorophyll *a* concentration is less than the chlorophyll *a* concentration that would be predicted from the nutrients associated with aquatic macrophyte community (Figure 7). Knowlton et al. (1984) reported that the temporal variation in chlorophyll *a*

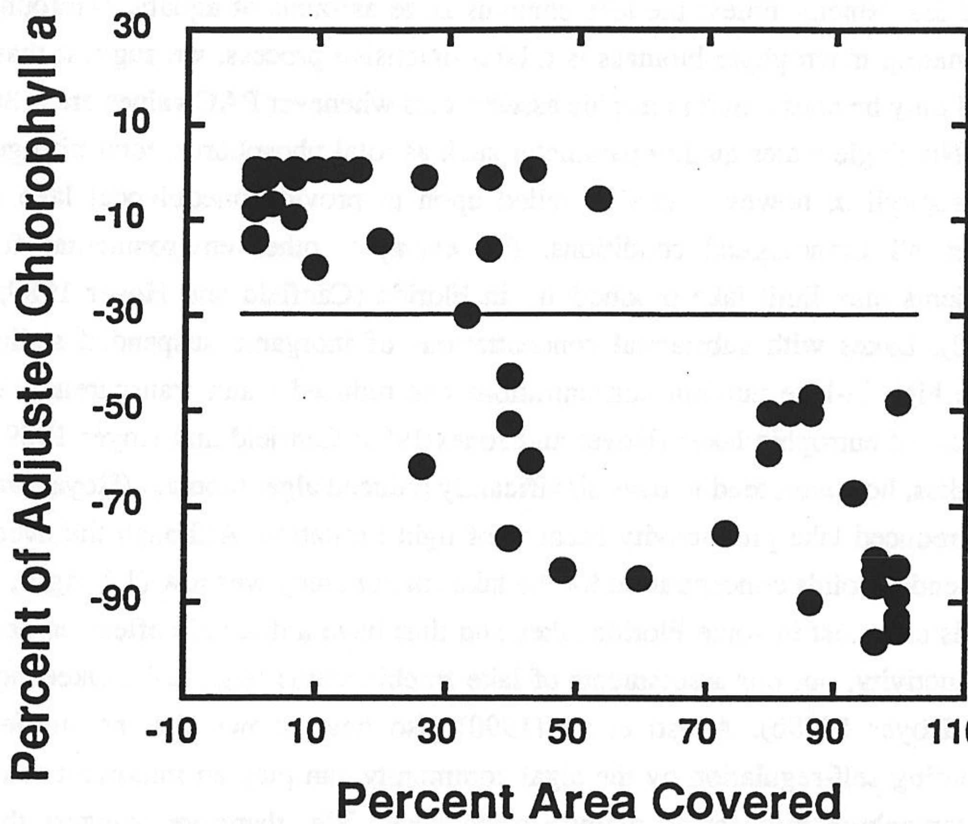

Figure 7. Relation between measured chlorophyll *a* as a percent of adjusted chlorophyll *a* and percent area covered with aquatic macrophytes for 60 Florida lakes. The line on the graph represent an approximation of the natural variability of chlorophyll *a* (± 30 % of the mean) in lake systems (Knowlton et al. 1984).

values in lakes ranges naturally about ± 30% of the mean value. Therefore, the depressed chlorophyll *a* values in Figure 7 do not exceed natural variability in chlorophyll *a* values (± 30% of the mean; Knowlton et al. 1984) for most lakes until PAC is between 30 and 50%. This strongly suggests that macrophytes probably do not need to be considered in trophic state assessments unless the lake contains large amounts of aquatic macrophytes. Because estimating macrophyte biomass is a labor-intensive process, we suggest that macrophytes need only be considered in trophic assessments whenever PAC values are ≥ 30%.

No single water quality parameter such as total phosphorus, total nitrogen or adjusted chlorophyll *a*, however, can be relied upon to provide unequivocal lake classifications under all limnological conditions. For example, other environmental factors besides nutrients may limit lake productivity in Florida (Canfield and Hoyer 1989; Agusti et al. 1990). Lakes with substantial concentrations of inorganic suspended sediment typically have high in-lake nutrient concentrations and reduced water transparency, characteristics typical of eutrophic lakes (Hoyer and Jones 1983; Canfield and Hoyer 1989). These types of lakes, however, tend to have significantly reduced algal biomass (Hoyer and Jones 1983) and reduced lake productivity because of light limitation. Although the average inorganic suspended solids concentration for the lakes in our study was low (1.1 mg/L, Table 8), high levels can exist in some Florida lakes and thus have a dramatic effect on not only on lake productivity, but our assessments of lake trophic status (e.g., Lake Okeechobee, Canfield and Hoyer 1988b). Agusti et al. (1990) also have shown that nonnutrient constraints including self-regulation by the algal community can play an important role in regulating phytoplankton biomass in many Florida lakes. We, therefore, suggest that individuals assessing the trophic status of Florida lakes remain cognizant of all the major limnological factors that can potentially influence lake trophic status.

Fish, Trophic State, and Aquatic Macrophyte Relations

Numerous studies have been conducted over the last 50 years to determine not only the environmental factors that regulate fish abundance in lakes, but to develop models that could predict fish yields from lakes (e.g., Rounsefell 1946; Rawson 1952; Carlander 1955; Moyle 1956). In the early 1960s, Ryder (1965) suggested that fish yields in lakes are related to total dissolved solids and lake mean depth and he proposed the morphoedaphic index (MEI), an empirically derived formula, that was described initially as a convenient method for rapidly calculating potential fish yields from unexploited north-temperate lakes. In recent years, the scientific and practical aspects of the MEI have been debated (Ryder et al. 1974), but it is now recognized that lake productivity is the primary determinant of fish abundance. Melack (1976) and McConnell et al. (1977) both reported strong relations between gross primary production and fish yield. Several investigators have also published empirical relations between total phosphorus and chlorophyll *a* concentrations and fish yield or standing crop (Oglesby 1977; Jones and Hoyer 1982; Hanson and Leggett 1982; Bays and Crisman 1983).

The theoretical basis for predicting fish yield or standing crop from chlorophyll *a* concentrations is that the average chlorophyll *a* concentration is an indicator of lake trophic status (Carlson 1977; Forsberg and Ryding 1980). Chlorophyll *a* concentrations have been correlated with nutrient concentrations (Jones and Bachmann 1976), photosynthetic production (Smith 1979; Beaver and Crisman 1991), suspended organic solids (Jones and Hoyer 1982) and zooplankton abundance (Patalas 1972; McCauley and Kalff 1981; Canfield and Watkins 1984). Thus, any research efforts examining environmental factors that are reported to influence fish populations should first examine lake trophic status to determine its relative importance (Hoyer et al. 1985).

When we averaged our estimates of total and harvestable fish abundance (expressed on a weight basis) by lake trophic status for our study lakes, we found that fish abundance as estimated by use of either rotenone sampling (Figure 8), experimental gillnets (Figure 9) or electrofishing (Figure 10) increased with lake trophic status. These relationships are not only consistent with conventional wisdom, but with the numerous published relations between fish standing crop or yield and measures or correlates of lake trophic status (Oglesby 1977; Jones and Hoyer 1982; Hanson and Leggett 1982; Bays and Crisman

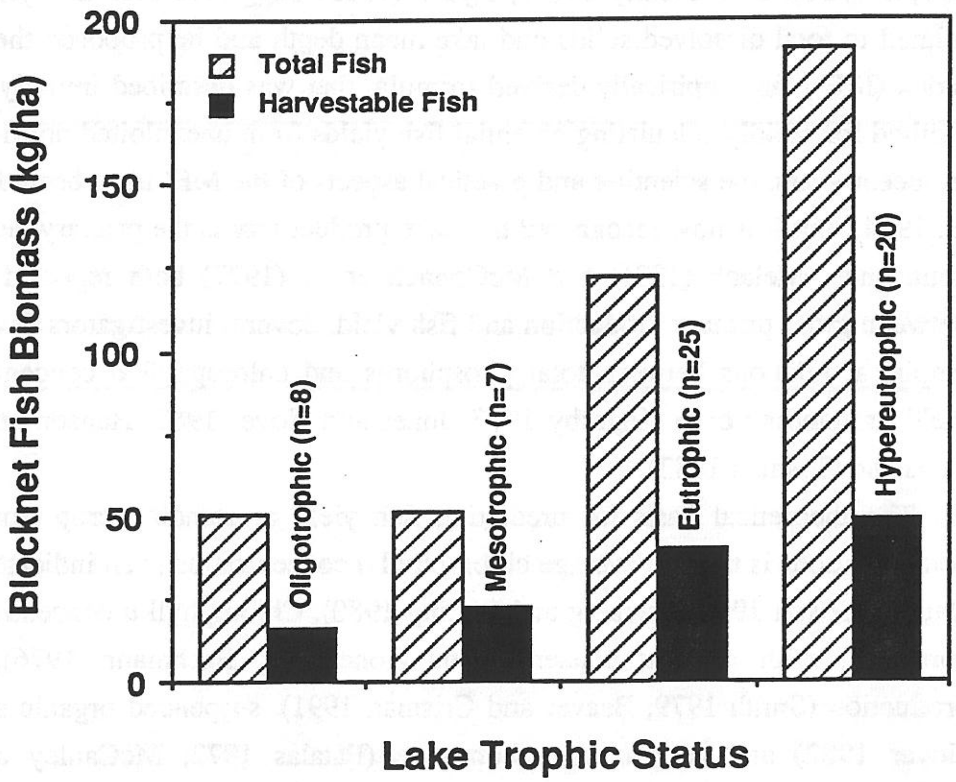

Figure 8. Total and harvestable fish biomass (kg/ha), as estimated by rotenone sampling, and averaged by lake trophic status for 60 Florida lakes. The number of lakes in each trophic category is listed on the graph.

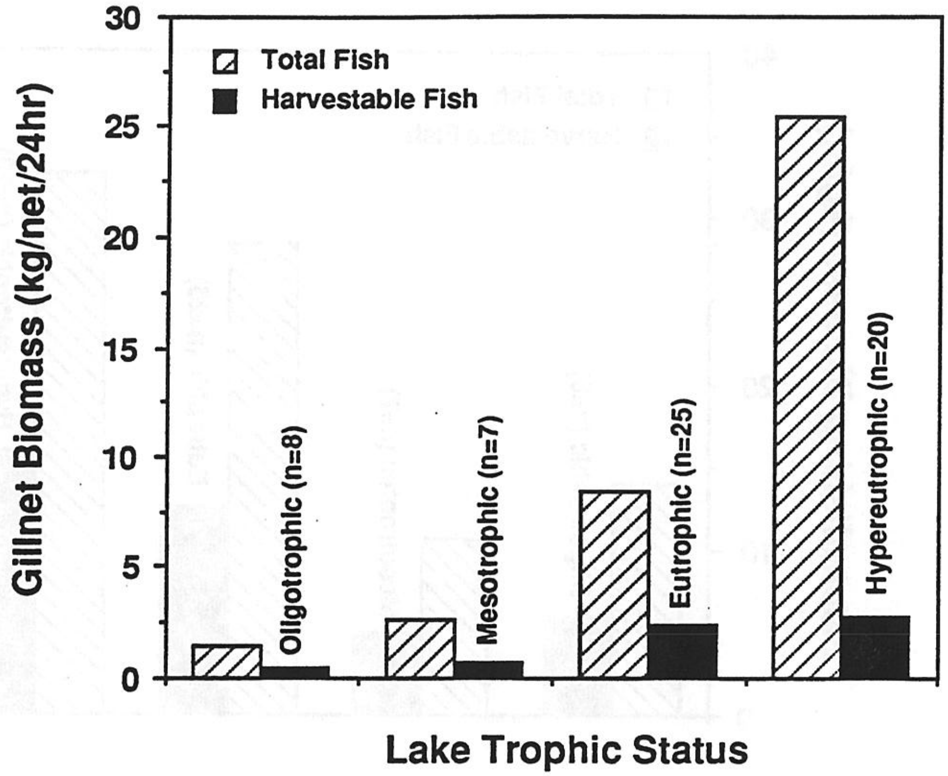

Figure 9. Total and harvestable fish biomass (kg/net/24 hr), as estimated with experimental gillnets and averaged by lake trophic status for 60 Florida lakes. The number of lakes in each trophic category is listed on the graph.

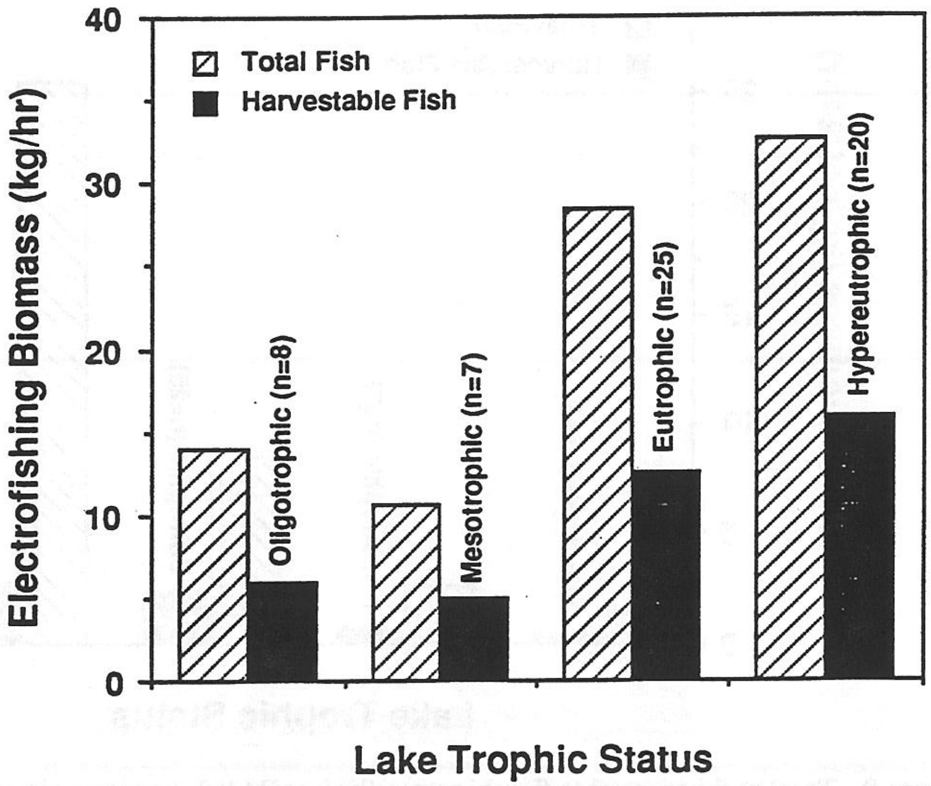

Figure 10. Total and harvestable fish biomass (kg/hr), as estimated by electrofishing sampling, and averaged by lake trophic status for 60 Florida lakes. The number of lakes in each trophic category is listed on graph.

1983). Using regression analysis and the data for each lake, we also showed that total and harvestable fish abundance (expressed on a weight basis) were significantly related to adjusted chlorophyll *a* concentrations for rotenone sampling, gillnets, and electrofishing (Table 249).

Although there are statistically significant relations between estimates of total and harvestable fish abundance and adjusted chlorophyll a values among lakes (Table 249), the relationships are weak because estimates of fish abundance can vary as much as 500% for a given adjusted chlorophyll level (Figure 11 and 12). LOWESS regression analysis (SYSTAT 1989), however, suggested that there is a positive relationship between total fish biomass and adjusted chlorophyll *a* despite the tremendous variability encountered in our sampling (Figure 11). We also found a weak positive trend between harvestable sportfish biomass and adjusted chlorophyll *a* concentrations using the LOWESS regression technique, but there is much more variability in the harvestable sportfish biomass-adjusted chlorophyll *a* relationship (Figure 12). There are several possible explanations for the weaker harvestable fish biomass-adjusted chlorophyll *a* relation including: 1) harvestable fish populations can be significantly impacted by angling (Porak et al. 1990a) and 2) as lake trophic state increases the percentage of the total fish biomass represented by sportfish tends to decreases (Kautz 1980; Bays and Crisman 1983).

The tremendous variability in fish abundance for a given trophic level that we have documented for Florida lakes (Figure 11 and 12) is not unique to Florida (see Ryder et al. 1974; Melack 1976; McConnell et al. 1977; Oglesby 1977; Jones and Hoyer 1982; Hanson and Leggett 1982). Numerous biotic and abiotic factors have been suggested as causative agents for the large variance in fish biomass at a given trophic level, but many scientists over the last century have suggested that aquatic macrophytes are the major factor influencing fish populations (Reighard 1915; Klugh 1926; Smith and Swingle 1941; Bailey 1978). This has led to the general belief among many aquatic scientists that aquatic macrophytes are extremely important to functioning of lakes. This belief is especially strong in Florida where many fisheries studies have suggested the importance of aquatic macrophytes to sportfish populations (e.g., Moxley and Langford 1982; Schramm et al. 1984; Porak et al. 1990a).

Table 249. Regression models relating total and harvestable fish abundance estimated with rotenone sampling (kg/ha), experimental gillnets (kg/net/24hr) and electrofishing (kg/hr) to lake trophic status as estimated with adjusted chlorophyll *a* values (µg/L, see methods for calculation).

Model	Standard Error of the estimate	r
Blocknet Fish Abundance Samples:		
Log (Total) = 1.56 + 0.28 Log (Adjusted Chlorophyll *a*)	0.38	0.43[a]
Log (Harvestable) = 1.14 + 0.15 Log (Adjusted chlorophyll *a*)	0.47	0.20[a]
Gillnet Fish Abundance Samples:		
Log (Total) = -0.11 + 0.61 Log (Adjusted chlorophyll *a*)	0.59	0.55[a]
Log (Harvestable) = -0.39 + 0.34 Log (Adjusted chlorophyll *a*)	0.39	0.52[a]
Electrofishing Fish Abundance Samples:		
Log (Total) = 0.92 + 0.22 Log (Adjusted Chlorophyll *a*)	0.41	0.32[a]
Log (Harvestable) = 0.49 + 0.28 Log (Adjusted Chlorophyll a)	0.50	0.33[a]

a = statistically significant at $p \leq 0.10$

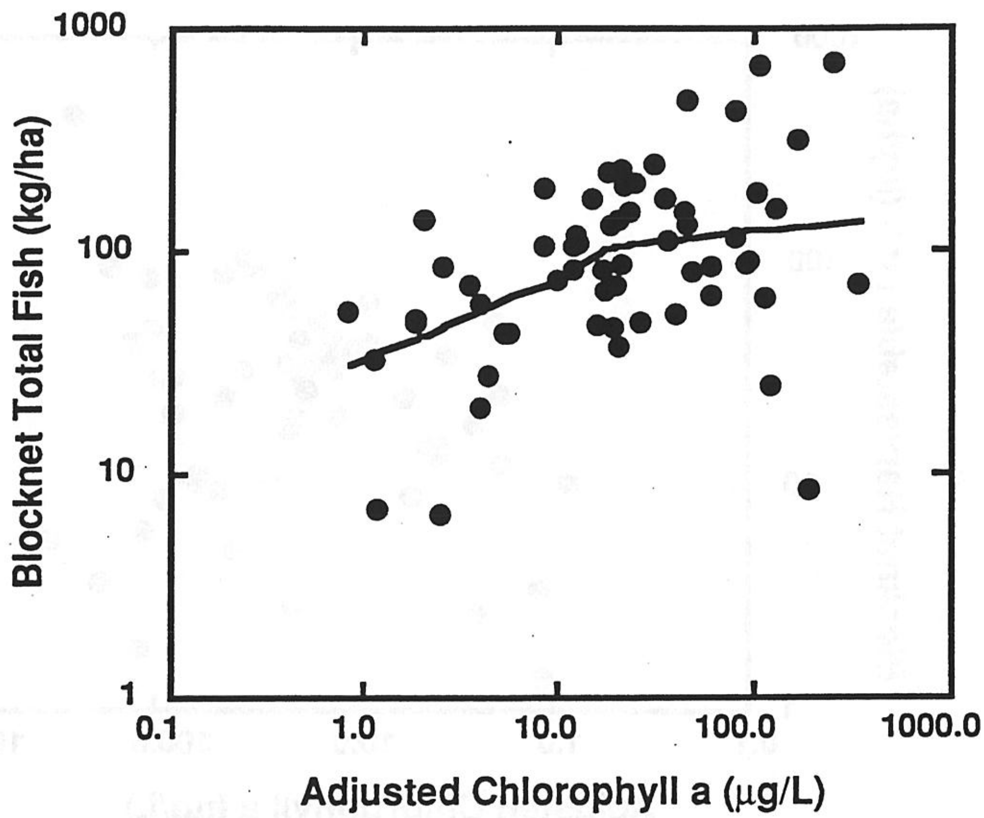

Figure 11. Relation between total fish biomass (kg/ha), as estimated with blocknets and adjusted chlorophyll *a* concentrations (µg/L) for 60 Florida lakes. Adjusted chlorophyll *a* was calculated by adding the chlorophyll *a* that

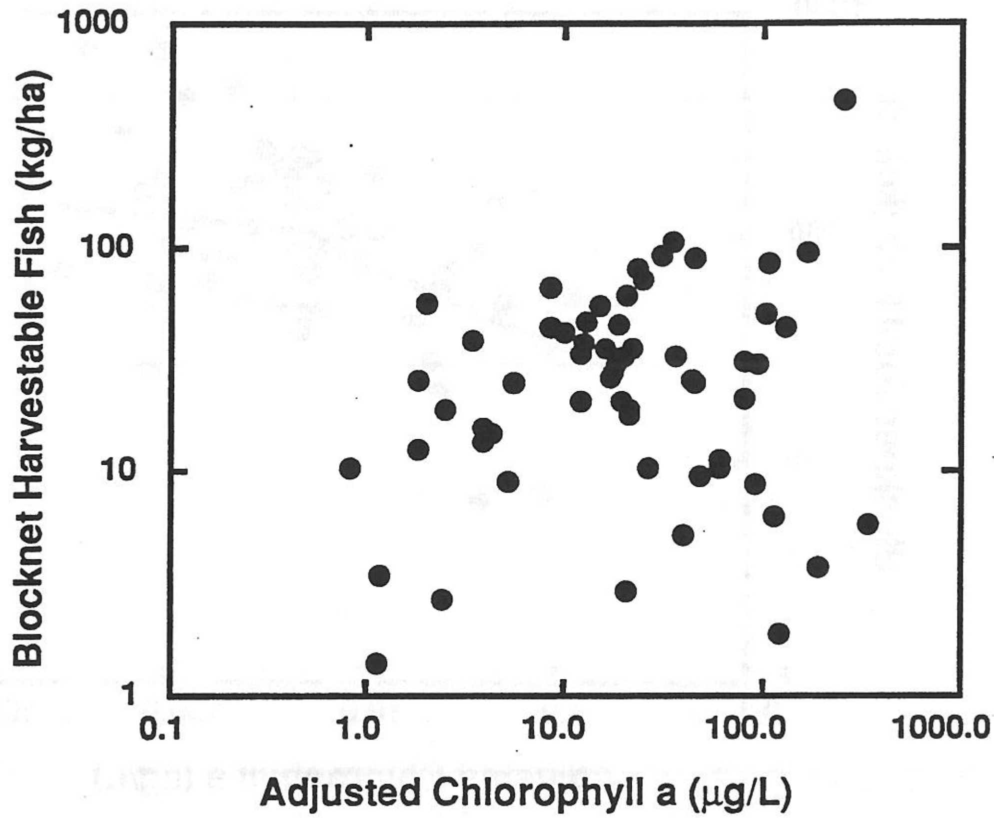

Figure 12. Relation between harvestable fish biomass (kg/ha), as estimated with blocknets and adjusted chlorophyll *a* concentrations (µg/L) for 60 Florida lakes. Adjusted chlorophyll *a* was calculated by adding the chlorophyll *a* that would be predicted from the nutrients incorporated in aquatic plant and epiphytic algal tissue to the measured chlorophyll *a* according to the

None of the measures of aquatic macrophyte abundance that we measured during this study were significantly ($p \leq 0.05$) correlated to either total or harvestable fish biomass as estimated with rotenone sampling (Table 250). Although we did not find any direct correlations between total or harvestable fish biomass (kg/ha) and the percent area covered with aquatic macrophytes for our 60 study lakes (Figures 13a and 13b), correlation analysis of data from the individual lakes does not directly consider lake trophic status. Because lake trophic status is a major factor determining total and harvestable fish biomass in a wide range of lake systems (Table 249; Figure 8, 9 and 10), we calculated a fish biomass to adjusted chlorophyll *a* ratio (e.g., g fish biomass/g chlorophyll *a*). We then plotted this ratio against each lake's PVI value (Figure 14 and 15). We used PVI instead of PAC to avoid any possible autocorrelation that might be caused by using PAC in the calculation of the adjusted chlorophyll *a* values.

Table 250. Correlation coefficient between seven aquatic macrophyte parameters and fish biomass estimates for 60 Florida lakes. Both total and harvestable fish biomass values were estimated with rotenone sampling and weighted by littoral and open water habitats. The probability values for each correlation coefficient are listed in parentheses.

	Blocknet Fish Biomass Estimates (kg/ha)	
Parameter	Total Fish	Harvestable Fish
Emergent biomass (kg/m^2)	0.04 (0.75)	-0.04 (0.75)
Floating-leaved biomass (kg/m^2)	0.22 (0.10)	0.22 (0.10)
Submersed biomass (kg/m^2)	-0.12 (0.38)	-0.06 (0.64)
Total lake plant concentration (g/m^3)	0.05 (0.72)	0.01 (0.95)
Width of emergent and floating-leaved plant zone (m)	-0.05 (0.71)	0.11 (0.38)
Percent area covered with macrophytes	-0.05 (0.68)	-0.02 (0.75)
Percent volume infested with macrophytes	-0.07 (0.61)	-0.09 (0.48)

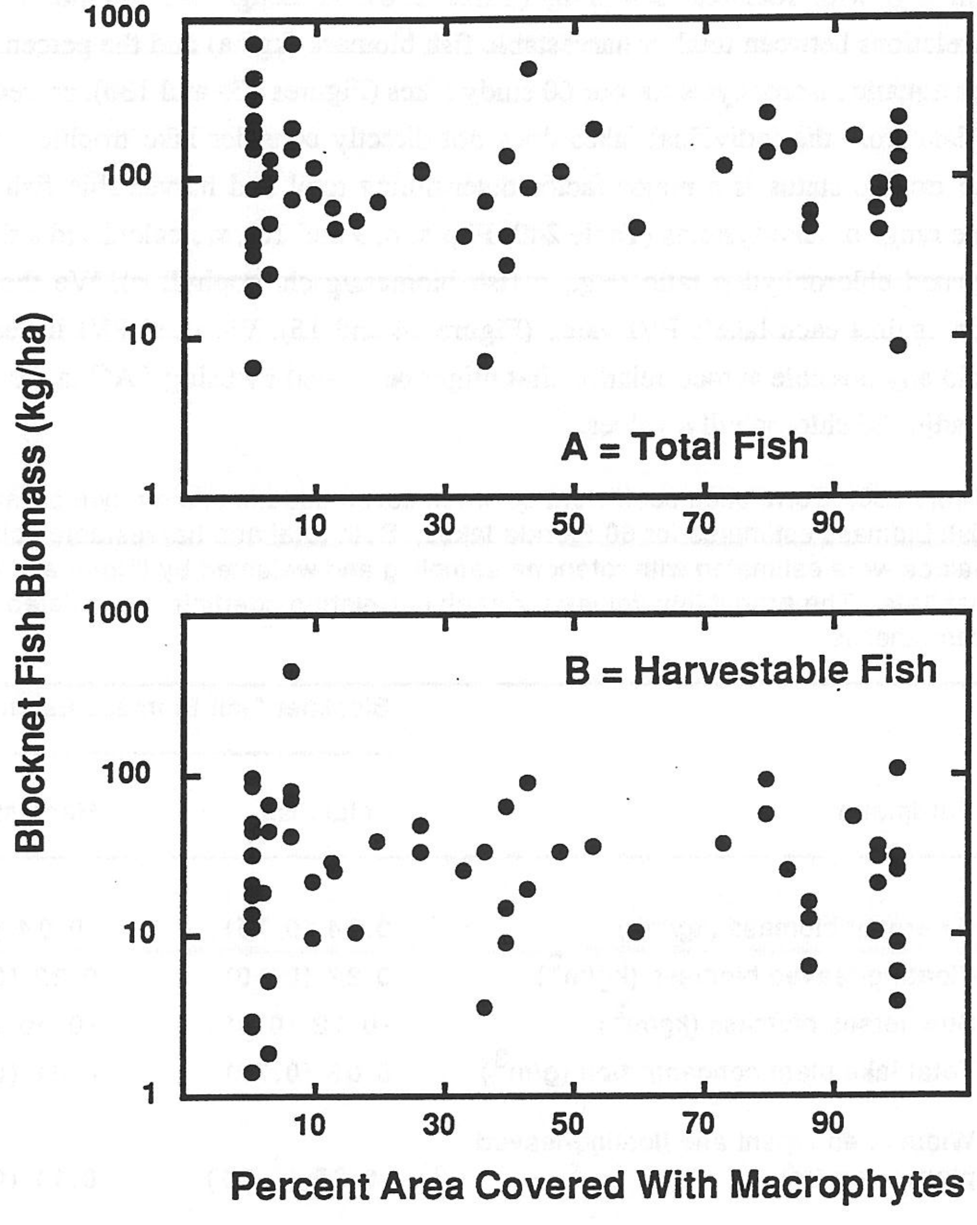

Figure 13. Relation between total fish biomass (A, kg/ha) and harvestable fish biomass (B, kg/ha), as estimated with rotenone sampling, and percent area covered with aquatic macrophytes for 60 Florida lakes.

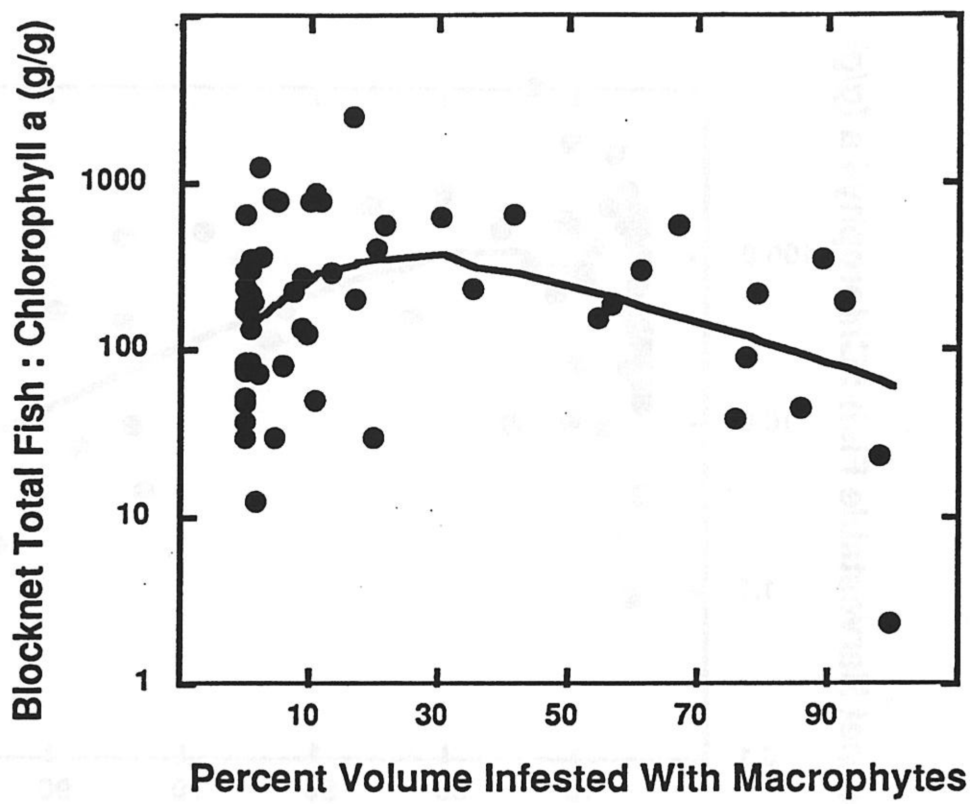

Figure 14. Relation between blocknet total fish biomass to adjusted chlorophyll *a* ratio (g fish biomass/g chlorophyll *a*) and percent volume infested with aquatic macrophytes for 60 Florida lakes. The plotted line is a locally-weighted regression line (LOWESS, Cleveland 1979, 1981).

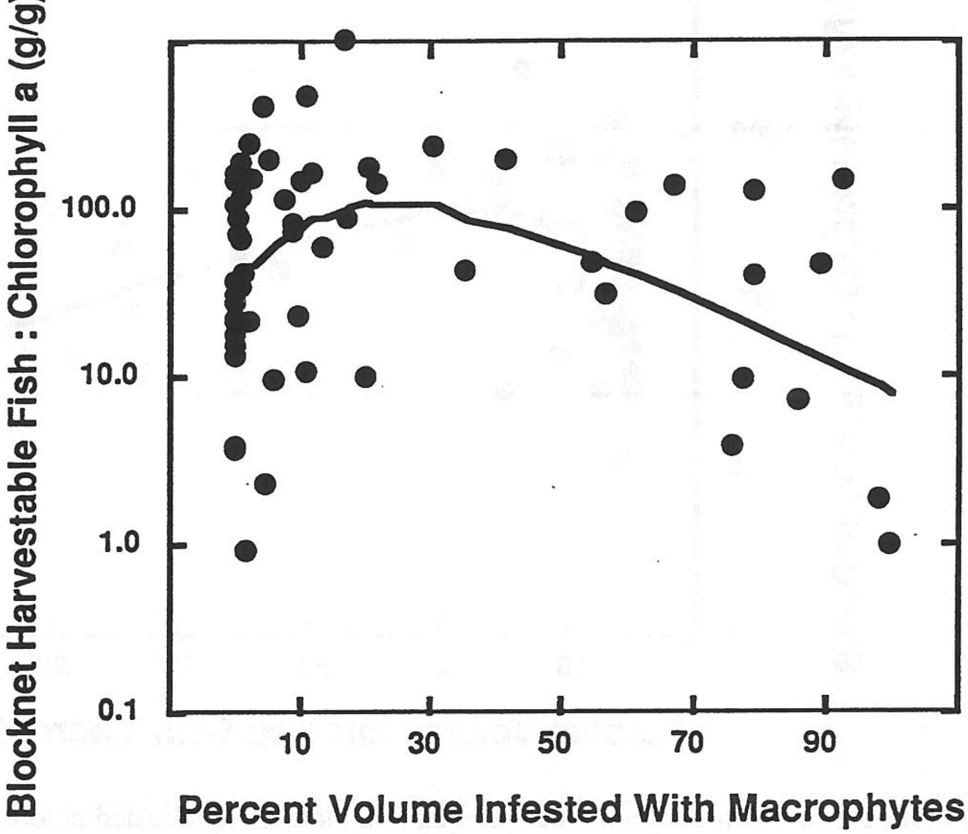

Figure 15. Relation between blocknet harvestable fish biomass to adjusted chlorophyll *a* ratio (g fish biomass/g chlorophyll *a*) and percent area covered with aquatic macrophytes for 60 Florida lakes. The plotted line is a locally weighted regression line (LOWESS, Cleveland 1979,1981).

To determine if there was any relationship between the total or harvestable fish biomass-adjusted chlorophyll *a* ratios and PVI, we plotted the LOWESS locally-weighted regression lines on Figures 14 and 15. For both total (Figure 14) and harvestable fish (Figure 15), the LOWESS trend lines indicate that the fish biomass-chlorophyll *a* ratio tends to be low at both low and high PVI values. The LOWESS trend lines also indicate that the fish biomass-chlorophyll *a* ratios reach a maximum between 20% and 40% PVI. To further examine the potential impact of large amounts of aquatic vegetation on fish populations, we plotted the ratio of harvestable fish biomass to chlorophyll *a* (Figure 16) against the total lake plant concentration (total lake plant biomass divided by lake volume, g/m^3), a measure of structural complexity (see Wiley et al. 1984). The LOWESS trend line for this relationship suggests that the fish biomass-chlorophyll *a* ratios are low at both low and high whole-lake plant concentrations with the harvestable fish biomass-chlorophyll *a* ratios reaching a peak between 10 and 50 g/m^3.

To visually examine the relations among lake trophic status, aquatic macrophyte abundance and fish populations simultaneously, we constructed three dimensional surface plots of total and harvestable fish biomass (kg/ha; estimated with rotenone sampling) and adjusted chlorophyll *a* concentrations (µg/L) and percent volume infested with aquatic macrophytes (Figure 17 and 18). The surface plots were produced by using the distance weighted least squares smoothing procedure (SYSTAT 1989). The surface plots suggest that both total and harvestable fish biomass increase with adjusted chlorophyll *a* concentrations throughout the range of adjusted chlorophyll *a* values in lakes with low levels of aquatic vegetation (Figure 17 and 18). At low levels of adjusted chlorophyll *a*, the surface plots indicate that both total and harvestable fish biomass increase with increases in PVI.

Aquatic macrophytes are reported to provide an abundance of invertebrates and small fish as food organisms (Gerking 1957; Barnett and Schneider 1974; Schramm et al. 1987), refuge from predation for forage and predator fish species (Wegener and Williams 1974; Wiley et al. 1984), and spawning substrate (Horel 1951; Kramer and Smith 1962; Chew 1974). Macrophytes also protect spawning nests from the scouring effects of wind and wave action (Kramer and Smith 1962; Holcomb et al. 1975; Shirley and Andrews 1977). The general parabolic shape of the LOWESS trend lines (Figure 14, 15, and 16) and the surface plots suggests that some intermediate macrophyte abundance should be optimum

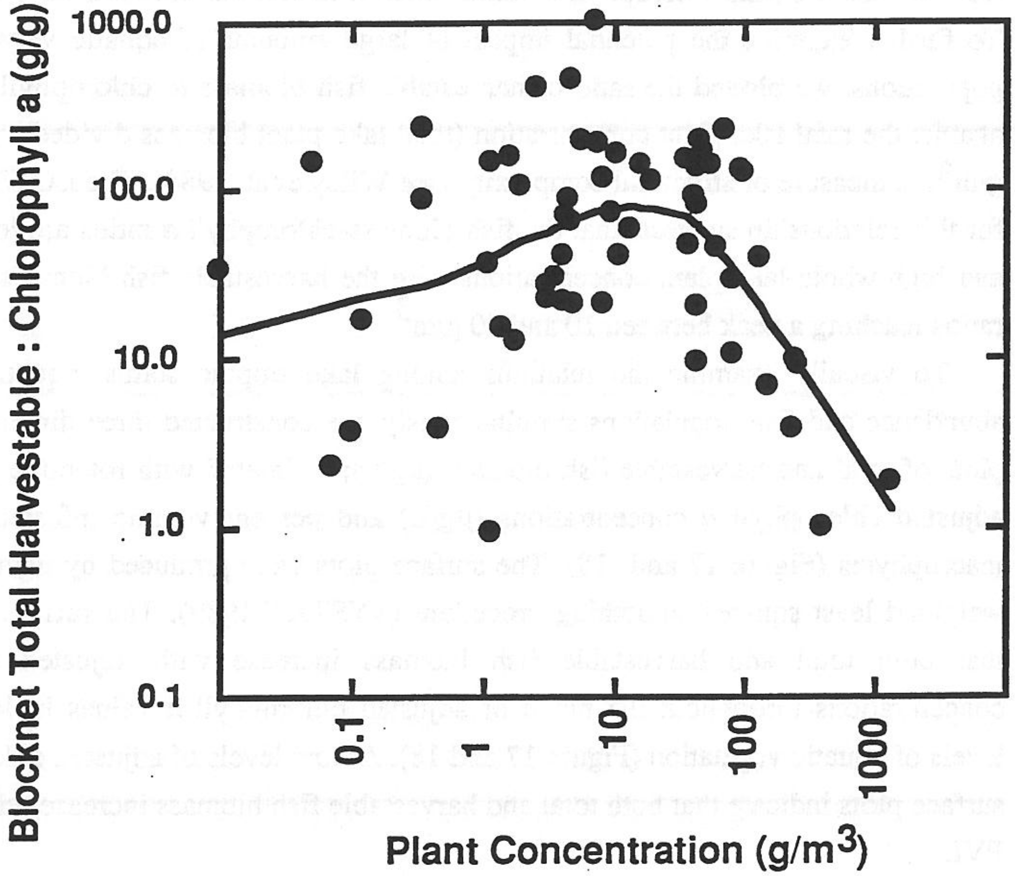

Figure 16. Relation between blocknet harvestable fish biomass to chlorophyll *a* ratio (g fish/g chlorophyll *a*) and total lake plant concentration (g/m^3), for 60 Florida lakes. The plotted line is a locally-weighted regression line (LOWESS, Cleveland 1979, 1981).

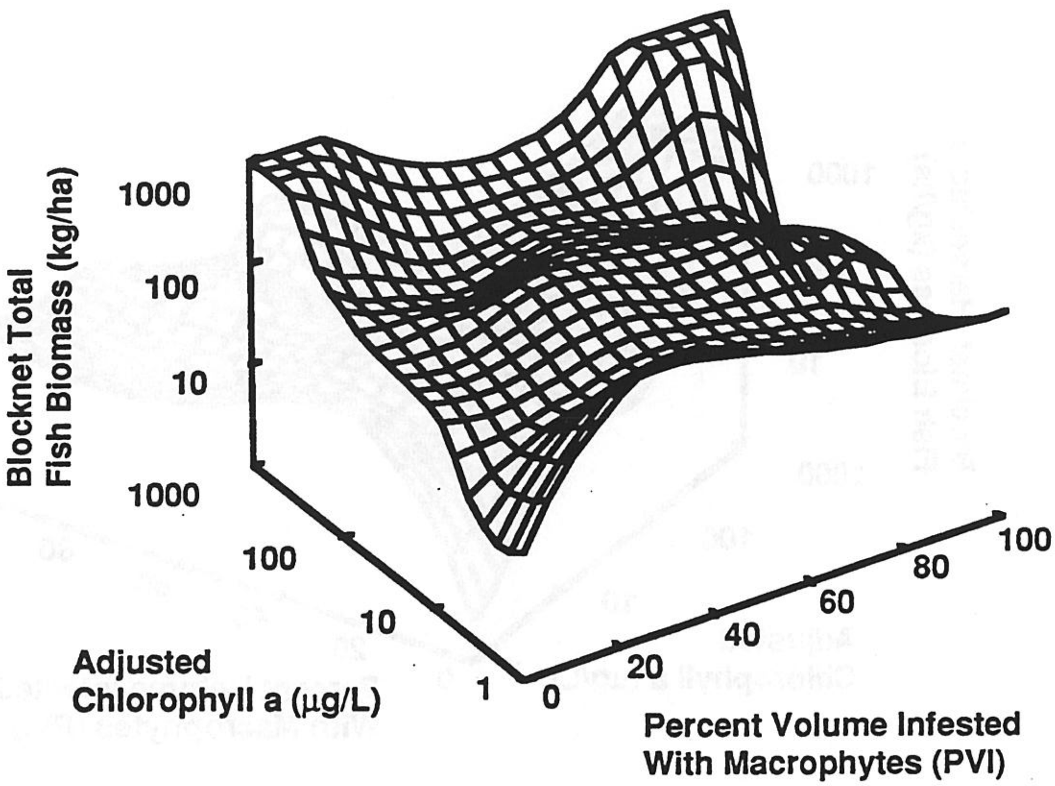

Figure 17. Three dimensional surface plot calculated using distance weighted least squares smoothing procedures (SYSTAT 1989), relating adjusted chlorophyll *a* concentrations (μg/L), percent volume infested with macrophytes, and blocknet total fish biomass (kg/ha).

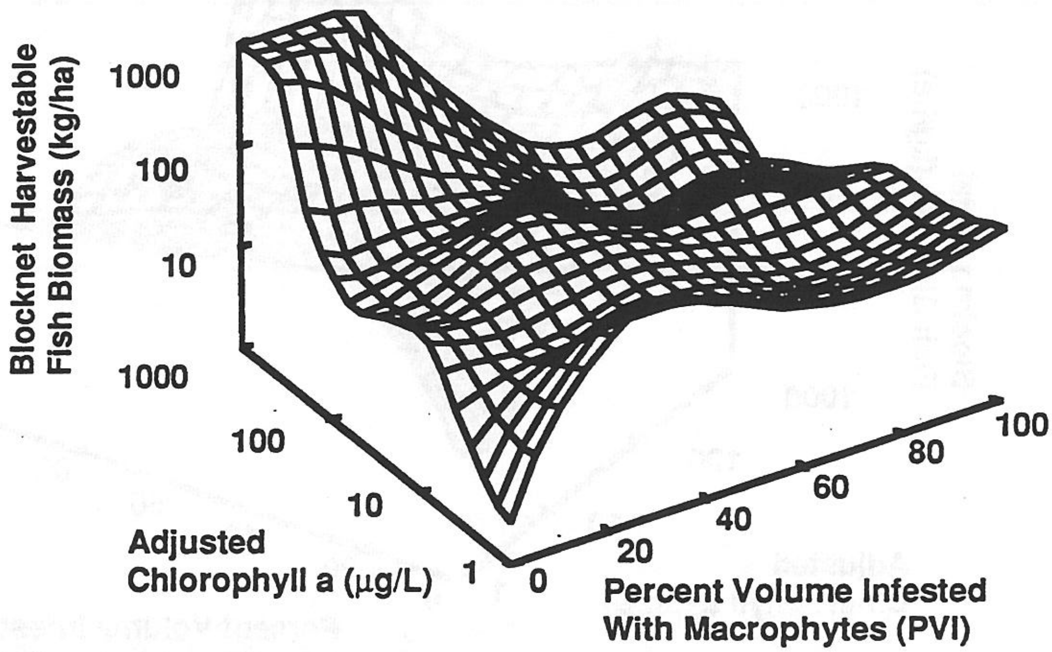

Figure 18. Three dimensional surface plot calculated using distance weighted least squares smoothing procedures (SYSTAT 1989), relating adjusted chlorophyll *a* concentrations (µg/L), percent volume infested with macrophytes, and blocknet harvestable fish biomass (kg/ha).

for fish populations. This finding supports several hypotheses in the primary literature (Cooper and Crowder 1979; Savino and Stein 1982; Wiley et al. 1984). For example, the low fish biomass-chlorophyll *a* ratios at high PVI values (Figure 14 and 15) and high plant concentrations (Figure 16) are consistent with the hypothesis that state high levels of aquatic vegetation can negatively impact fish populations. Excessive aquatic vegetation has caused stunted bluegill populations (Shireman et al. 1983) and reduced fish growth and condition (Bennett 1948; Buck et al. 1975; Colle and Shireman 1980; Maceina and Shireman 1985). A possible explanation for the decrease in growth and condition of fish in lakes with abundant aquatic vegetation is that the vegetation may interfere with the feeding of predator and forage fish species by increasing the structural complexity of the system (Crowder and Cooper 1979; Saiki et al. 1979; Mittelbach 1981; Savino and Stein 1982). Supporting this hypothesis, there is a significant inverse relation between the length of age I largemouth bass (mm TL) and the percent area covered with aquatic macrophytes (Figure 19).

Although our survey results seem to add further support for the need of at least some aquatic vegetation in Florida lakes for fish populations, it is important to state here that the the LOWESS trend lines and the surface plots only suggest the probability of a decrease in fish biomass per unit of chlorophyll *a* at low and high levels of aquatic vegetation. Some of our study lakes with PVI values < 20% and some with PVI values > 75% have high total and harvestable fish standing crops. Four lakes, however, with the lowest harvestable fish biomass to chlorophyll *a* ratio in the < 20% volume infested vegetation group included three grass carp lakes (Lake Holden, Clear Lake and Lake Wales) and Lake Apopka. This suggests that the long-term removal of aquatic vegetation, especially by the use of grass carp, may increase the probability of having a depressed fish population. We state "probability" because other lakes (e.g., Lake Baldwin, Bell Lake and Lake Orienta) that have had vegetation removed with grass carp for long periods of time (about 10 years) have shown no negative impacts on fish populations (see the discussion on grass carp).

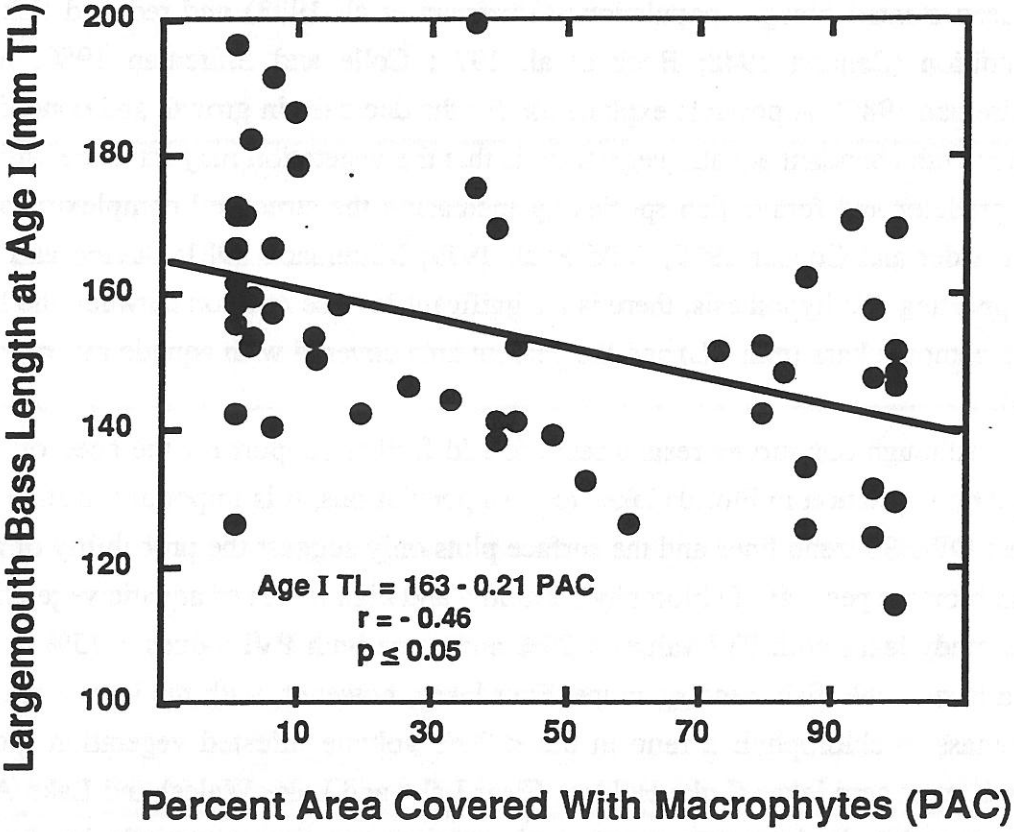

Figure 19. Relation between largemouth bass length at age I (mm TL) and percent area covered with aquatic macrophytes (PAC) for 57 Florida lakes. Length at age I was backcalculated from otolith examinations according to the methods of Hoyer et al. 1985.

Grass Carp Lakes

Eight of our study lakes (Lake Baldwin, Bell Lake, Clear lake, Lake Holden, Lake Killarny, Lake Orienta, Lake Pearl and Lake Wales) were sampled to determine the long-term effect of complete vegetation removal on water quality and fish populations. These lakes were stocked with diploid grass carp at stocking rates ranging from 20 to over 400 fish/ha to experimentally manage aquatic plants (principally hydrilla). The grass carp, however, when used at these stocking rates eventually removed nearly all aquatic macrophytes. Submersed vegetation has been completely eliminated from the lakes for 10 to 15 years (e.g., Figure 3, 4 and 5) and only remnant populations of some floating-leaved vegetation (e.g., *Nuphar luteum*), filamentous algae (e.g., *Lyngbya* sp.) and encroaching shoreline vegetation (e.g., *Ludwigia octovalis* and *Colocasia esculenta*) remain. Thus grass carp can be a very successful long-term biological control for aquatic macrophytes, if the management objective is the complete removal of aquatic vegetation.

Florida now uses sterile triploid grass carp for the biological control of aquatic vegetation because there were fears that diploid grass carp might reproduce in Florida's lakes (Clugston and Shireman 1987). The triploid grass carp growth and behavior are similar to the diploid fish and information reported for lakes stocked with diploid fish seems be applicable to lakes stocked with triploid fish (Cassani and Caton 1986). The current trend in the use of triploid grass carp, however, is to stock low numbers (< 10 fish/ha) of fish in order to maintain some aquatic vegetation (Leslie et al. 1987). Although there are reports of maintaining at least 20% coverage of aquatic macrophytes in at least one lake with triploid grass carp (e.g., Lake Conway; Schardt and Nall 1981; Leslie et al. 1987), there still exists the potential for the complete elimination of aquatic macrophytes.

All aquatic vegetation can be eliminated from a lake if some natural or human-induced event reduces aquatic macrophyte coverage and biomass in a lake to a level where vegetation production is less then grass carp consumption rates. For example, Mill Dam, one of several examples, was stocked in 1987 and 1988 with approximately 6 fish/ha (assuming no mortality to stocked fish) to control hydrilla. In 1985, the percent area covered with aquatic macrophytes was 27% (Canfield and Joyce 1985). Two years after the initial stocking of triploid grass carp, the coverage of aquatic macrophytes was 33% (Table 3) and this coverage seemed stable until 1990 when Florida experienced an extreme drought. The drought caused the surface area of Mill Dam to decrease by about 40%, which concentrated the grass carp on the remaining vegetation. We sampled Mill Dam during May 1991 and found that macrophytes had been eliminated from the lake. Thus, the use of triploid (or diploid) grass carp in lakes where some macrophytic vegetation is desired will remain problematic until some method of removing the fish is developed.

The effects of aquatic macrophytes on water quality and the effects of aquatic macrophyte removal by use of grass carp on the water quality of Lake Baldwin, Lake Pearl and Lake Wales were discussed in detail earlier (see Influence of Aquatic Macrophytes on Algal Biomass, Water Transparency, and Lake Trophic State Classifications). For lakes supporting abundant growths of aquatic macrophytes (> 30% PAC), the removal of aquatic macrophytes will ultimately lead to increases in some trophic state parameters (e.g., total phosphorus, total nitrogen and chlorophyll *a* concentrations) and a decrease in water clarity as measured by use of a Secchi disc. These changes, however, are not specific to the use of grass carp because similar changes occur when other aquatic macrophyte management techniques such as aquatic herbicides are used (e.g., Buck et al. 1975; Carter and Hestand 1977). The changes also are not beyond what would be expected based on each lake's nutrient loading rate and lake morphology (e.g., Lake Baldwin; Shireman et al. 1984). For example, the relations between total phosphorus, total nitrogen, and chlorophyll *a* concentrations suggest that the eight long-term grass carp lakes are functioning similar to other Florida lakes (Figure 20 and 21). The grass carp lakes are also at trophic levels that are similar to that of other regional lakes, which is described by the ecoregion concept (see Canfield and Hoyer 1988a). The removal of aquatic macrophytes therefore simply resulted in a functional and structural shift to a phytoplankton-based ecosystem (Canfield et al. 1983a).

Grass carp do not compete for food or prey upon native North American fish species (Rottman and Anderson 1978; Shireman and Hoyer 1986). Thus, the effects grass carp may have on fish populations will be the indirect result of vegetation removal (Bailey 1972, 1975). The observations of several investigators on the effect that grass carp have had on fish populations are not consistent. Ware and Gasaway (1978) reported a deleterious effect on fish populations in two Florida ponds that received total vegetation removal with grass carp. Bailey (1978), however, after an examination of total standing crop, shad biomass, number of catchable largemouth bass, sunfish, crappie, and young-of-year sunfish and

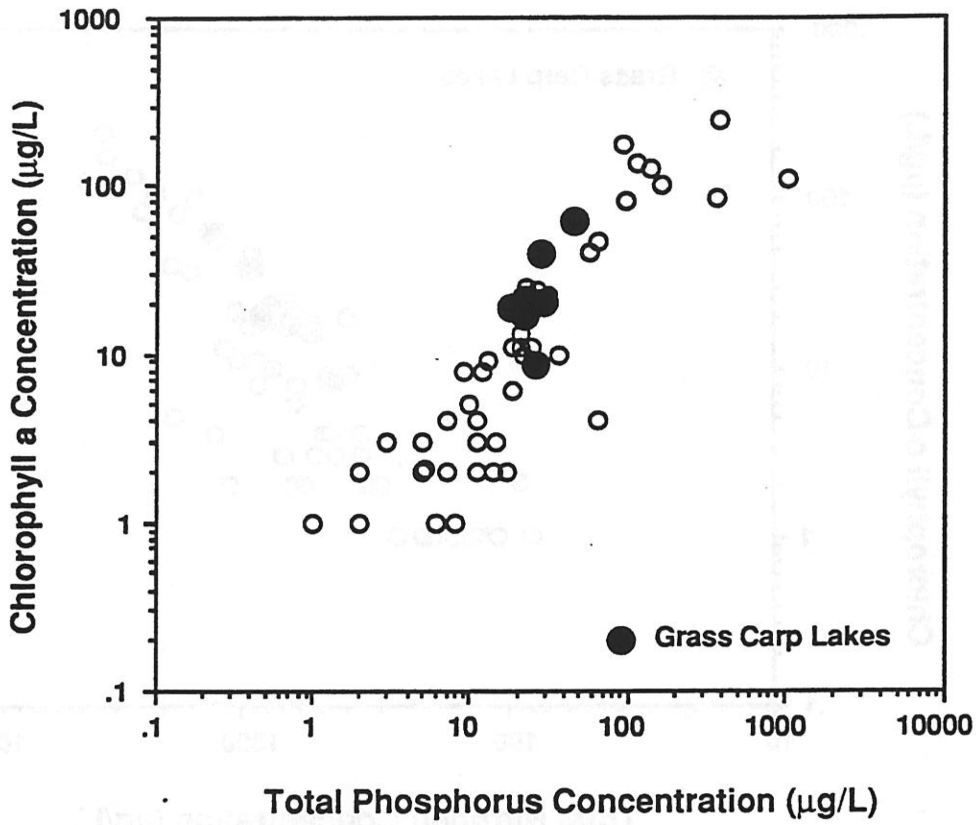

Figure 20. Relation between total phosphorus and chlorophyll *a* concentrations for 60 Florida lakes. The highlighted lakes are lakes that have received total elimination of vegetation with grass carp for 10 to 15 years.

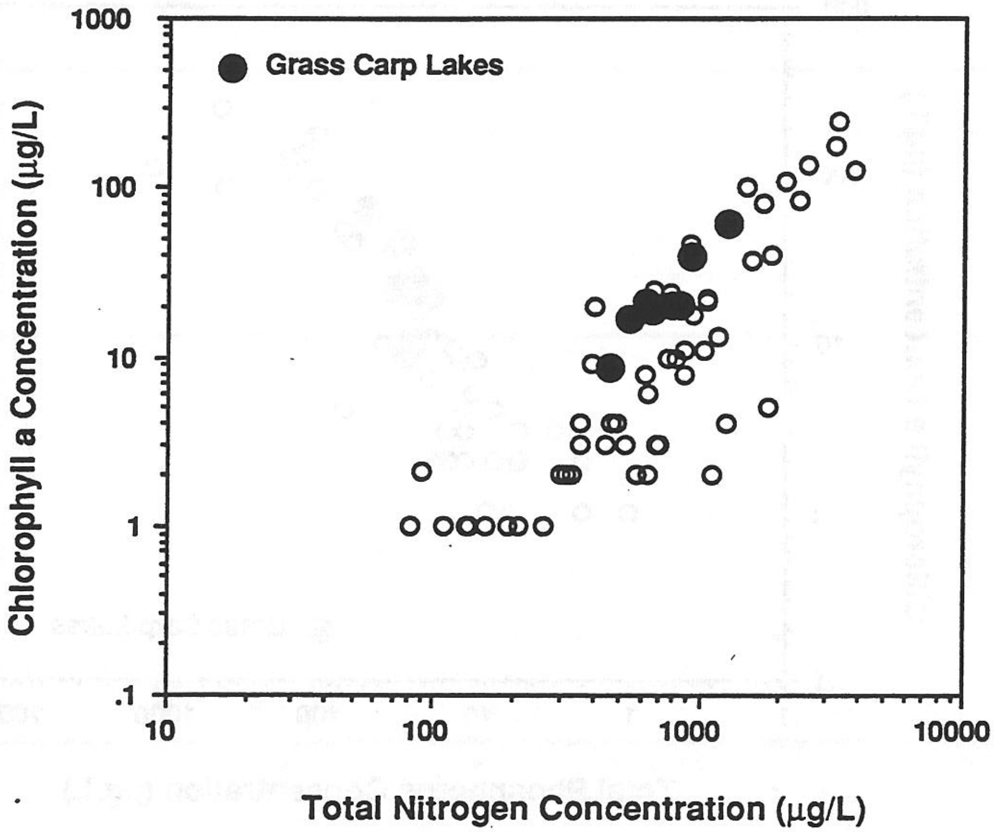

Figure 21. Relation between total nitrogen and chlorophyll *a* concentrations for 60 Florida lakes. The highlighted lakes are lakes that have received total elimination of vegetation with grass carp for 10 to 15 years.

largemouth bass for 31 Arkansas lakes stocked with grass carp, reported both increases and decreases with no trend in either direction. Total and harvestable fish biomass and total number of fish species remained constant in Lake Baldwin, Florida after grass carp had removed the macrophyte community (Shireman and Hoyer 1986). The total biomass of forage fish decreased about 60% after macrophyte removal in Lake Conroe, Texas, but sufficient forage remained for the predatory fish species in the lake (Klussmann et al. 1988). Although the density of age-I largemouth bass declined following the macrophyte removal, changes were not evident in either the density or biomass of largemouth bass > 240 mm TL. The abundance of channel catfish, yellow bass and white bass, however, increased in Lake Conroe after total elimination of hydrilla with grass carp (Klussmann et al. 1988).

There are long-term fisheries data for Lake Baldwin, Lake Pearl and Lake Wales (Colle and Shireman, University of Florida, unpublished data; Hanlon 1989), which are three of the grass carp lakes that we sampled for this study. Analyses of the fisheries data obtained from rotenone sampling indicates that there is no consistent relation between the fish populations of all three lakes and the removal of aquatic macrophytes. Total fish biomass in Lake Pearl and Lake Wales seems to have decreased with macrophyte removal, but Lake Baldwin's total fish population seems to have remained unaffected (Figure 22). The stock of harvestable bluegill, redear sunfish and largemouth bass declined in Lake Wales (Figure 23) after macrophyte removal as did the harvestable largemouth bass population in Lake Pearl (Figure 24). Lake Pearl's harvestable redear sunfish population, however, increased after macrophyte removal. Harvestable bluegill, redear sunfish and largemouth bass stocks also increased in Lake Baldwin after total vegetation removal with grass carp (Figure 25).

Bailey (1978) suggested that other variables such as weather, water level fluctuations, fertilization, and fishing pressure may have a more profound influence upon fish populations than the removal of aquatic macrophytes with grass carp. Concurrent with the loss of macrophytes at Lake Wales, there has been a steady decline in water level due to long-term rainfall deficits in the Lake Wales Ridge area of central Florida (Palmer et al. 1986; Hanlon 1989). The large and steady decline in water level experienced by Lake Wales may also have contributed to reduced fish populations. In 1978, Lake Pearl was essentially an undeveloped lake, but the lake had homes on 75% of the shoreline by 1990.

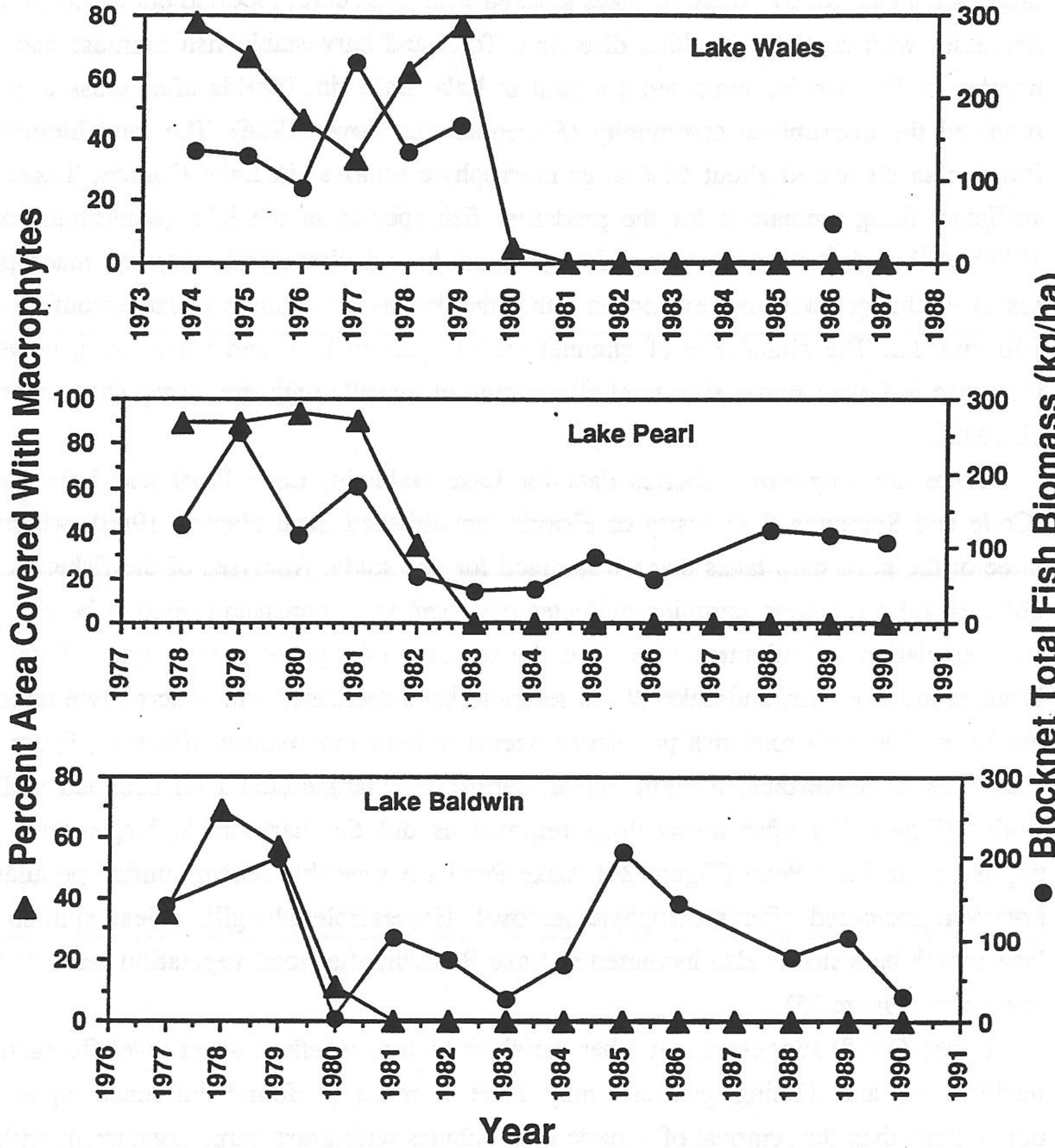

Figure 22. Long-term blocknet total fish biomass and macrophyte coverage data for Lake Wales, Lake Pearl, and Lake Baldwin (Colle and Shireman, unpublished data).

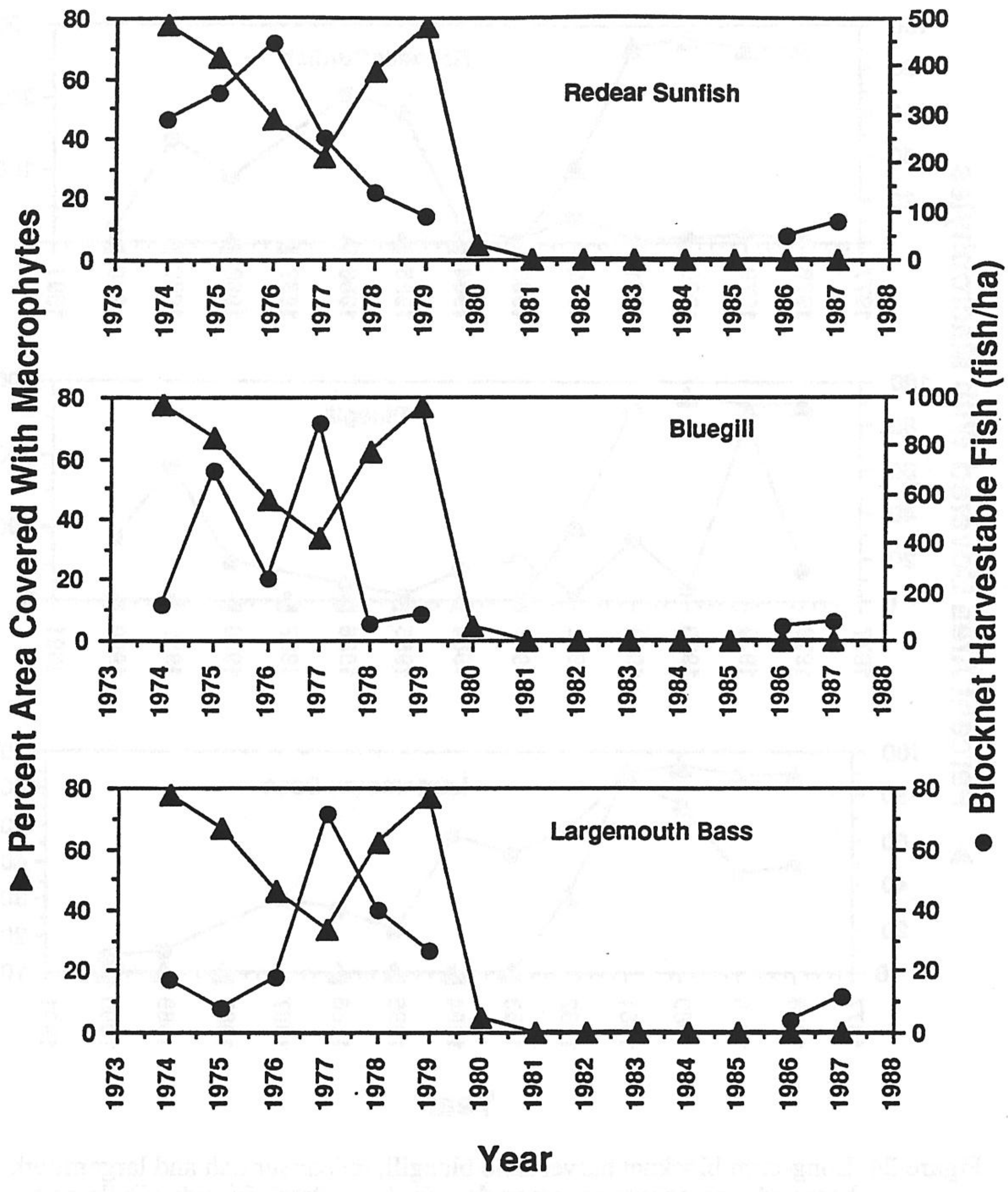

Figure 23. Long-term blocknet harvestable bluegill, redear sunfish and largemouth bass and macrophyte coverage data for Lake Wales, Florida (Colle and Shireman, unpublished data).

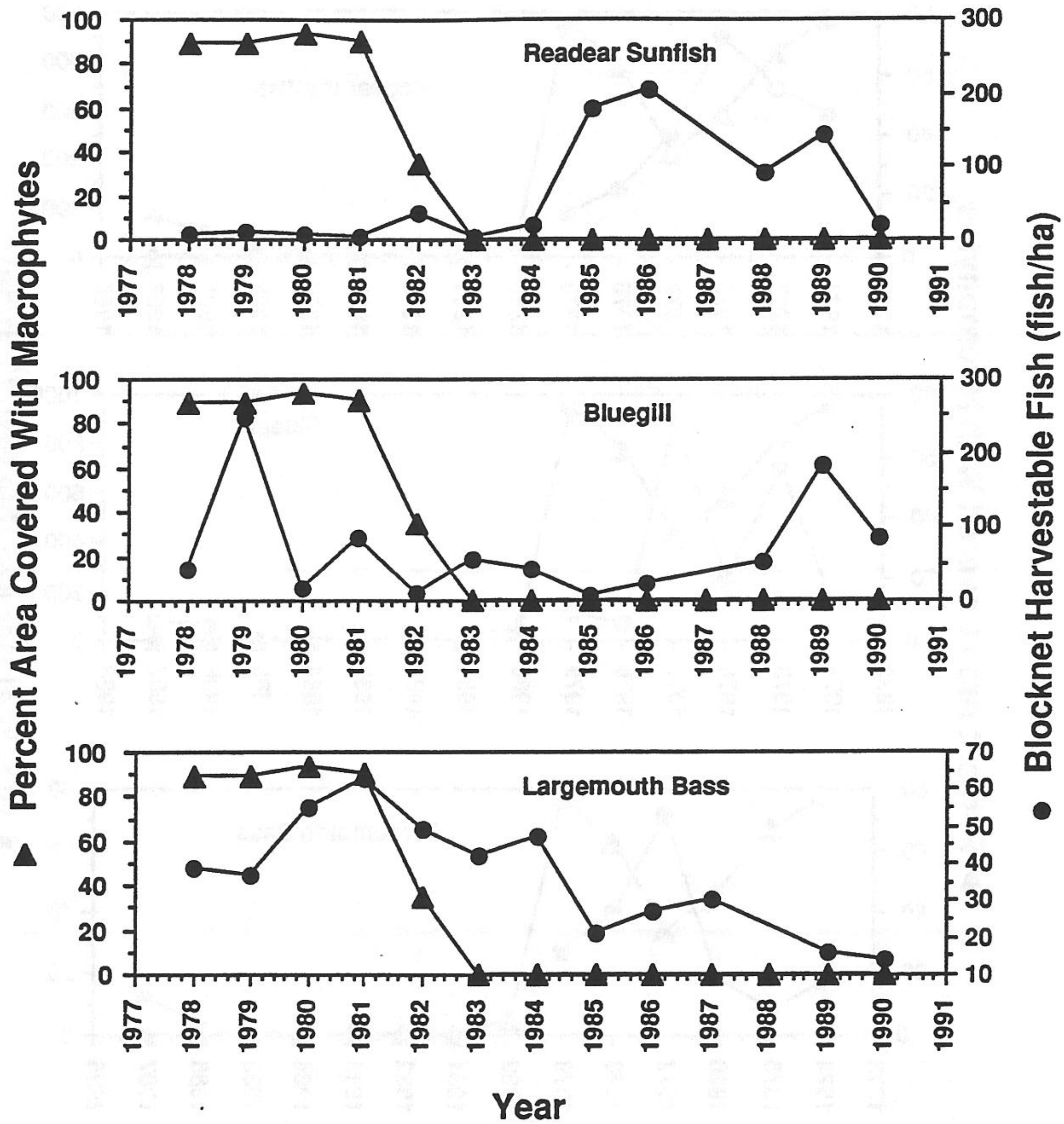

Figure 24. Long-term blocknet harvestable bluegill, redear sunfish and largemouth bass and macrophyte coverage data for Lake Pearl, Florida (Colle and Shireman, unpublished data).