Aquatic Vegetation and Water Quality in Lake Marion, South Carolina

by

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Introduction

Dense stands of aquatic vegetation have a significant effect on water quality (Buscemi 1958; Ultsch 1973; Schreiner 1980; Wylie and Jones 1987) and fish habitat (Engel 1988). Dense growth of aquatic vegetation in a reservoir can decrease the amount of vertical mixing that occurs in the water column, decrease lateral flow and mixing, reduce turbulence and aeration, and promote thermal stratification. Buscemi (1958) found dissolved oxygen (DO) to be lower and more sharply stratified under dense beds of *Egeria densa* than in adjacent open water. Water temperatures were higher and DO concentrations lower under extensive surface mats of water hyacinth (*Eichhornia crassipes*) than in open-water areas of experimental ponds (Ultsch 1973; Schreiner 1980). Wylie and Jones (1987) related diel and seasonal changes of DO and pH to the aquatic macrophyte community of a shallow reservoir in southeast Missouri. It is generally recognized that aquatic vegetation, when present in significant amounts, has an important influence on the chemical and physical environments of impoundments.

Lake Marion, South Carolina, is a 44,000-ha impoundment composed of open water, standing submerged trees, and thick cypress swamps. Aquatic vegetation has become a serious problem in upper Lake Marion north of the Interstate-95 (I-95) bridge (Inabinette 1985). The shallow, nutrient-rich upper Lake Marion area is conducive to aquatic plant growth. Many areas of the lake have limited access because of extremely thick vegetation. This has hampered use of the lake by recreational hunters, anglers, and boaters. Lake Marion has a long history of nuisance aquatic vegetation problems, dating back to large-scale alligator weed (*Alternanthera philoxeroides*) infestation in the 1940s (Inabinette 1985). Water quality studies have been completed on both Lake Marion and the Santee Swamp (Inabinette 1985; Harvey, Pickett, and Bates 1987; Bates and Marcus 1989). There have also been assessments of the distribution of aquatic vegetation on Lake Marion (Welch, Fung, and Remillard 1985) and the species of vegetation present in the lake (Inabinette 1985). No studies have attempted to determine the relationship between aquatic vegetation and water quality in Lake Marion, nor have the seasonal changes in species composition of aquatic vegetation been investigated.

Three hundred thousand triploid grass carp (*Ctenopharyngodon idella*) were stocked in upper Lake Marion between 1989 and 1991 for the purpose of vegetation control (South Carolina Aquatic Plant Management Council and South Carolina Water Resources Commission 1989). Current data are needed in order to assess the impact of this measure on water quality and aquatic vegetation. The objectives of this study were to (a) determine the changes in aquatic vegetation abundance and water quality over the course of 1 year at five different areas in upper Lake Marion, (b) determine the seasonal changes in aquatic vegetation species composition at these five areas, and (c) determine the relationship between water quality and aquatic vegetation abundance in these five areas.

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Study Area

Lake Marion was formed in 1941 by the impoundment of the Santee River (Inabinette 1985). Wateree and Congaree rivers join to form Santee River about 15 km upstream from Lake Marion. Lake Marion is a eutrophic reservoir with an average depth of 4 m and a maximum depth of 23 m (Inabinette 1985).

Upper Lake Marion, the defined study area, is north of the I-95 bridge. This area has standing submerged trees, open shallow flats, and thick stands of bald cypress (*Taxodium distichum*) and water tupelo (*Nyssa aquatica)*. Upper Lake Marion has an estimated 4,800 ha of submerged vegetation. Santee Swamp is immediately upstream from upper Lake Marion and covers approximately 6,500 ha. The swamp is anaerobic for most of the year and affects the water quality of upper Lake Marion (Bates and Marcus 1989).

Five sampling areas were selected as representative of different habitat types present in the upper Lake Marion area (Figure 1). Three of the areas, Pack's Flats, Elliot's Flats, and

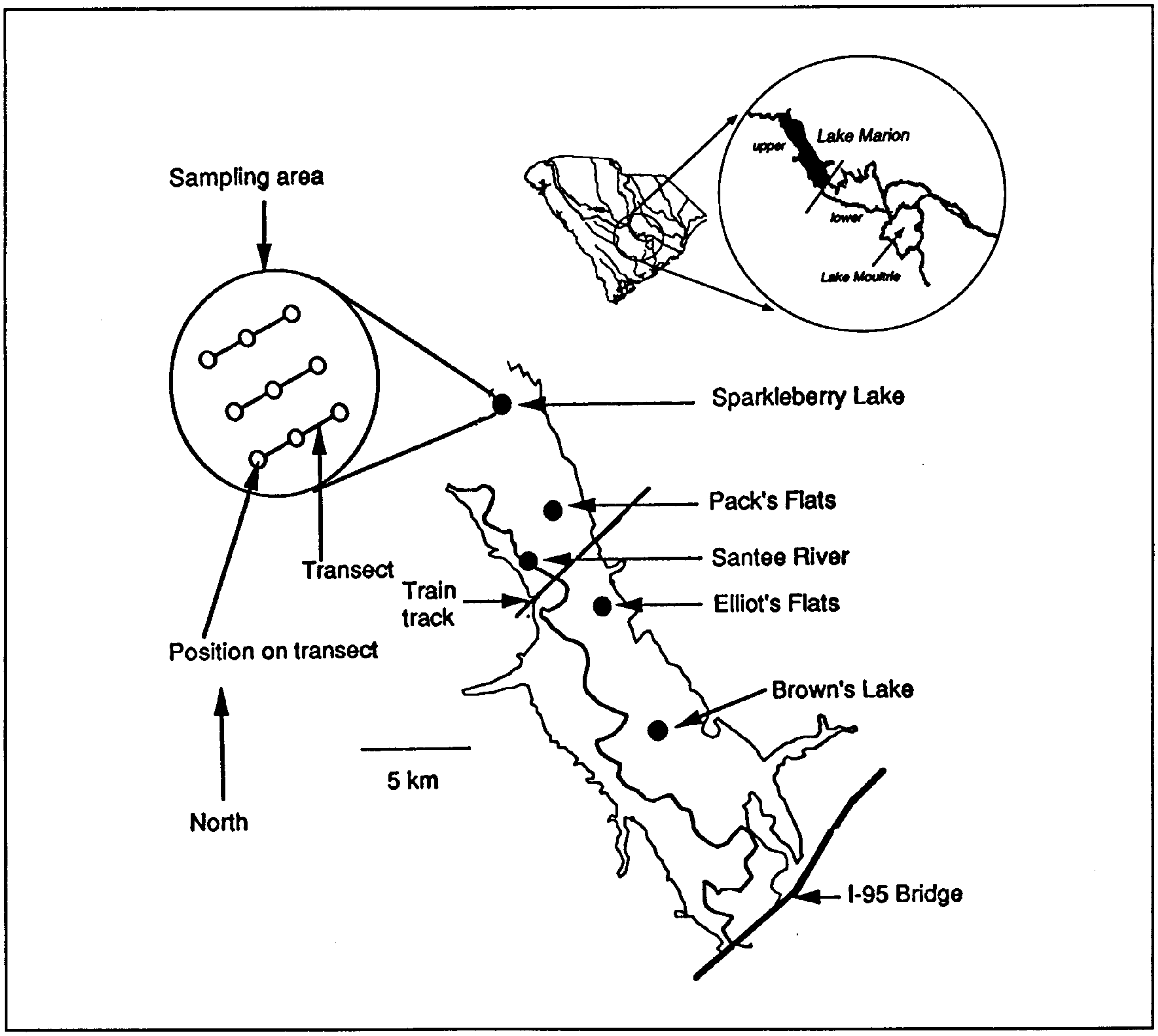

Figure 1. Location of upper Lake Marion on a map of South Carolina (top). Location of study areas in upper Lake Marion and a diagram of transects and positions in an area

Brown's Lake, were in upper Lake Marion proper. Pack's Flats is a shallow (depth = 1.0 to 2.0 m) open area in the uppermost region of Lake Marion near the Santee Swamp; hence water quality in Pack's Flats is strongly influenced by the Santee Swamp (Bates and Marcus 1989). Elliot's Flats sampling area is located approximately 3.5 km southeast of Pack's Flats. This area is slightly deeper (depth = 1.5 to 2.5 m) than Pack's Flats and receives water directly from the Santee River via a canal as well as some flow from smaller tributaries and the Santee Swamp. Brown's Lake is located approximately 7.5 km southeast of Elliot's Flats and approximately 1 km below the confluence of Lake Marion and the Santee River channel. It is a relatively deep area (depth 3.5 to 4.5 m) characterized by standing submerged trees. The other two sampling areas, Sparkleberry Lake and Santee River, are located in the Santee Swamp and in the Santee River, respectively. Sparkleberry Lake is a small (1 ha), shallow (depth = 1.0 to 1.5 m) lake in the lower end of the Santee Swamp. Santee River sampling area is located in the Santee River, channel 9 km above its confluence with Lake Marion. All of these areas experience considerable seasonal changes in water level and flow.

Methods

The five study areas were sampled biweekly for 12 months from January to December 1991. Three parallel transects 60 m long were marked 100 m apart in each area. Aquatic vegetation abundance and primary and secondary vegetation species were recorded at three equidistant positions along each transect for a total of nine readings per area per biweekly sampling period (Figure 1). DO concentrations, water temperature, and conductivity were also recorded at the surface and bottom at each position. Vegetation abundance was recorded as one of five categories for each position. Each category was assigned a numerical value. The categories and their numerical values were as follows: 0—no vegetation present, 1—vegetation sparse, 2—vegetation present but submersed, 3—vegetation surface coverage less than 50 percent, 4—vegetation surface coverage greater than 50 percent. Abundance values were summed for each transect resulting in three abundance values per area per sampling period, each with values from 0 to 12. Differences in vegetation abundance among biweekly sampling periods and differences in abundance among study areas were tested in separate one-way analysis of variance tests (ANOVA) (Harvey 1982; SAS Institute, Inc. 1985). A t-test on least squares means (Harvey 1982) was also performed to determine which areas differed significantly from other areas.

An aquatic vegetation sample was taken at each position with a rake. Primary vegetation species was the species that comprised the largest proportion of the sample. Secondary vegetation was the species comprising the next largest proportion. Vegetation was identified in the field (Aulbach-Smith and DeKoslowski 1990). Sampling periods were combined into four seasons to examine seasonal differences in primary vegetation species composition. The seasons were defined as follows: winter (December 21 - March 20), spring (March 21 - June 20), summer (June 21 - September 20), fall (September 21 - December 20). Two categories of primary vegetation were assigned numerical values: 1—*Hydrilla* and 0—other vegetation species. These two categories were used for the purpose of statistical analysis because of the predominance of *Hydrilla* as the primary vegetation species. The mean of the values was calculated for each area during each sampling period. This mean, which was between 0 and 1, represented the proportion of each area in which *Hydrilla* was the primary species of vegetation. Differences in this proportion among seasons and among areas were then analyzed using ANOVA (SAS Institute, Inc. 1985) and a t-test on least squares means (Harvey 1982). Secondary vegetation species were recorded at each position but were not included in statistical analysis. The Santee River study area was omitted from statistical analysis procedures on vegetation species composition and abundance because of the year-round absence of aquatic vegetation in the river channel.

DO concentration (to nearest 0.1 mg/L), water temperature (to nearest 0.1 °C), and conductivity (to nearest µmho/cm) were measured 10 cm below the surface and 10 cm above the bottom at each position. DO and temperature were measured with a Yellow Springs Instruments DO meter (Model 51 B).

Differences in DO concentrations, water temperature, and conductivity among areas and among sampling periods were analyzed using ANOVA and a t-test on least squares means. Differences between surface and bottom DO concentrations, surface and bottom temperature, and surface and bottom conductivity values were calculated for each area and a t-test performed with the null hypothesis that the difference = 0.

Pearson correlation coefficients were calculated for vegetation abundance and surface and bottom DO concentrations, temperatures, and conductivity values to determine if these parameters were correlated. All error testing was done at alpha = 0.05 level.

Water temperature and DO readings were taken at 30-cm intervals from surface to bottom on 17 September (week 36) and during July of 1992 and 1993 to examine differences in water quality throughout the water column in summer. Readings were taken at three positions in each area and the average of the three readings is reported. These readings were taken at all study areas except the Santee River.

Results

Vegetation abundance differed significantly among all study areas ($F = 184.3$, $p \leq 0.0001$) except Brown's Lake and Sparkleberry Lake ($p = 0.77$). Relative abundance rankings (on a scale of 0 to 12) averaged for the year were as follows: Pack's Flats = 9.12, Elliot's Flats = 7.13, Sparkleberry Lake = 2.43, Brown's Lake = 2.27. Relative abundance rankings differed significantly among sampling periods at Elliot's Flats ($F = 7.45$, $p \leq 0.0001$) and Pack's Flats ($F = 18.06$, $p \leq 0.0001$), but not at Brown's Lake ($F = 0.96$, $p = 0.5212$) or Sparkleberry Lake ($F = 1.61$, $p = 0.0822$). Figure 2 illustrates

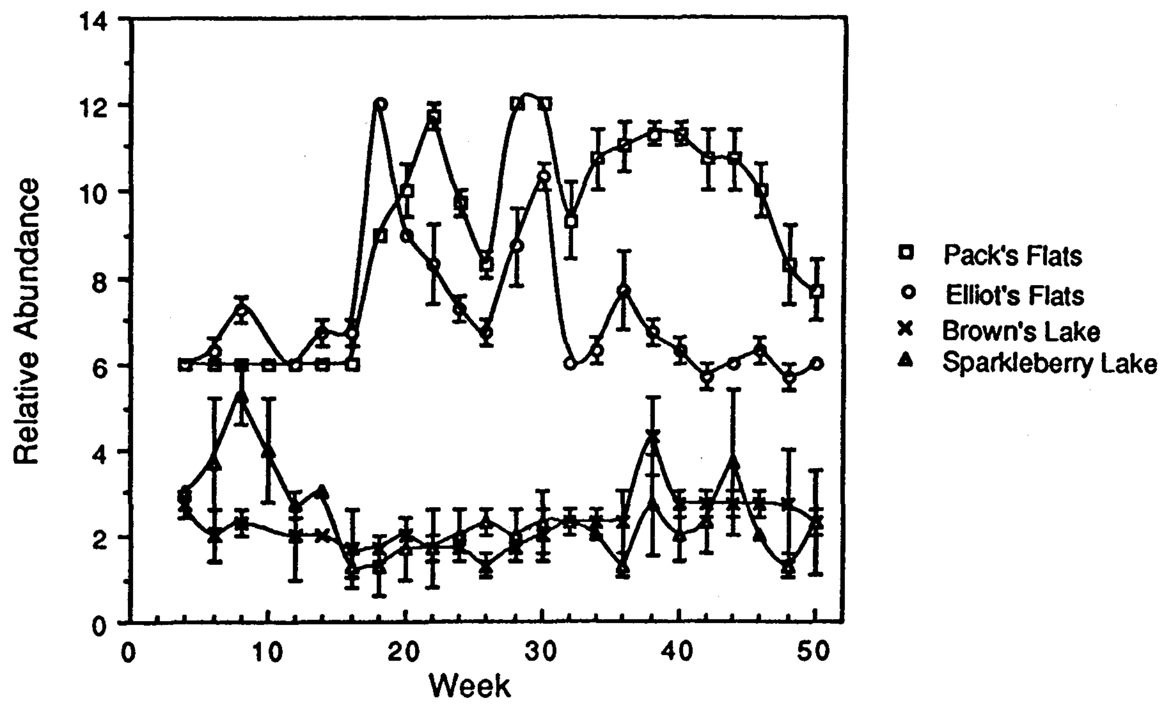

Figure 2. Relative vegetation abundance at four study areas in upper Lake Marion,South Carolina, during 1991

the changes in vegetation abundance over the course of the study. Brown's Lake had very little aquatic vegetation throughout the year, and a surface canopy of vegetation never formed. Sparkleberry Lake had small patches of both submersed and emergent vegetation throughout the year, but was never heavily infested. Sparkleberry Lake had slightly higher abundance values in late fall, winter, and early spring when there was little shading from the canopy of cypress and water tupelo trees. In contrast, Pack's Flats and Elliot's Flats were heavily infested with *Hydrilla* and other species of aquatic vegetation throughout the year. In the winter, aquatic vegetation was mostly submersed. As water temperatures and the photoperiod duration increased in spring and summer, vegetation increased, and a dense surface canopy formed at both areas. Elliot's Flats and portions of Pack's Flats were treated with aquatic herbicide by Santee Cooper Public Service Authority (to facilitate recreational access) during week 18 and week 29 of the study. Vegetation abundance in these two areas declined in late fall and winter as water temperature and the photoperiod duration decreased.

Vegetation abundance was significantly correlated with the following: surface DO ($R = 0.1977$, $p \leq 0.0001$), bottom DO ($R = -0.2717$, $p \leq 0.0001$), surface temperature ($R = 0.2172$, $p \leq 0.0001$), bottom temperature ($R = 0.1205$, $p = 0.0006$), surface conductivity ($R = 0.2392$, $p \leq 0.0001$), and bottom conductivity ($R = 0.2294$, $p \leq 0.0001$).

Hydrilla was the primary vegetation for 66 percent of the observations taken during the study (Figure 3). Other vegetation species included water primrose (*Ludwigia uruguayensis*), *Egeria densa*, coontail (*Ceratophyllum demersum*), *Potamogeton* spp., *Najas* spp., and *Bidens* spp. Primary vegetation differed significantly among all study areas ($F = 795.62$, $p \leq 0.0001$) except Pack's Flats and Elliot's Flats ($p = 0.13$). Primary vegetation did not differ significantly among seasons ($F = 1.58$,

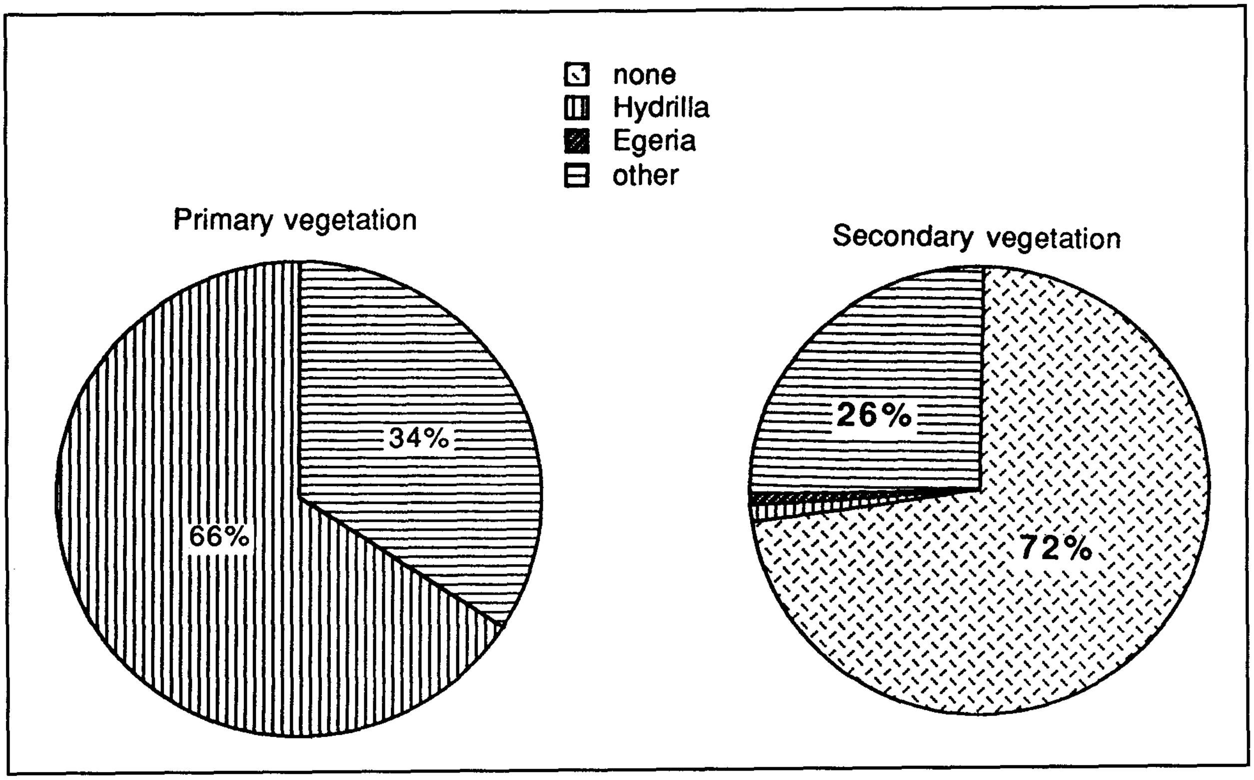

Figure 3. Primary and secondary species of aquatic vegetation at four study areas in upper Lake Marion, South Carolina, during 1991

p = 0.2003). No secondary vegetation was present for 72 percent of the observations (Figure 3). *Hydrilla* was the secondary vegetation species for only 1 percent of the observations. Other species of secondary vegetation are listed above.

DO levels were highest during January (week 2) and generally decreased throughout the year until late September (week 38) (Figures 4-8). At this time, DO concentrations began to rise and continued to do so through December (week 48). Lowest DO concentrations recorded for all areas were during the months of July, August, and early September. Surface DO levels differed significantly from bottom DO levels for all study areas ($t_{\text{Brown's Lake}} = 3.34$, $p \leq 0.0001$; $t_{\text{Elliot's Flats}} = 8.49$, $p \leq 0.0001$; $t_{\text{Pack's Flats}} = 13.00$, $p \leq 0.0001$; $t_{\text{Sparkleberry Lake}} = 9.19$, $p \leq 0.0001$; $t_{\text{Santee River}} = 8.68$, $p \leq 0.0001$).

Surface DO levels differed significantly among all study areas (F = 80.40, $p \leq 0.0001$) except Pack's Flats (Figure 4) and Santee River (Figure 5) (p = 0.11). Surface DO levels also differed significantly among sampling periods (F = 99.51, $p \leq 0.0001$). Elliot's Flats (Figure 6) and Pack's Flats areas exhibited the greatest biweekly fluctuations. Highest mean surface DO concentration recorded was 11.2 mg/L at Pack's Flats on 19 February (week 6) and 28 May (week 20) and at Sparkleberry Lake (Figure 7) on 19 March (week 10). Lowest mean surface DO concentrations recorded were 0.7 and 0.8 mg/L at Sparkleberry Lake on 11 July (week 26) and 03 September (week 34), respectively. Surface DO concentration was related to surface temperature and vegetation abundance (R-square = 0.91) (Figure 9). Surface DO concentrations increased as vegetation abundance increased and were highest at or below 10 °C and above 20 °C.

Bottom DO concentrations were usually lower than those at the surface and did not exhibit as much biweekly fluctuation (Figures 4-8). Bottom DO concentrations differed significantly among all study areas (F = 240.88,

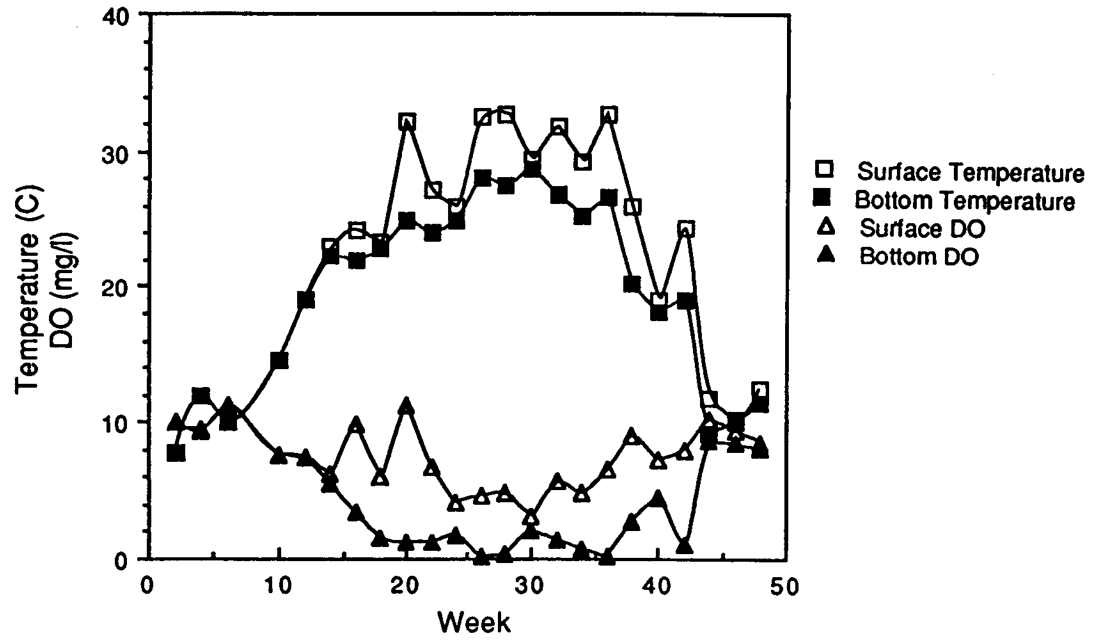

Figure 4. Surface and bottom temperature and DO levels at Pack's Flats, Lake Marion, South Carolina, during 1991

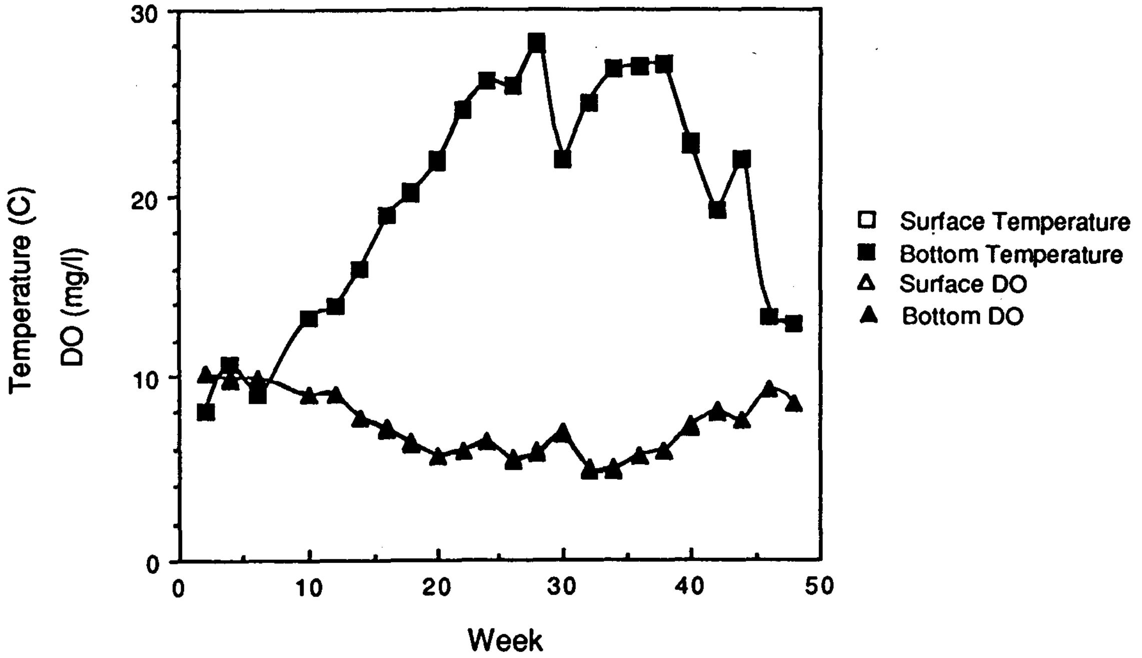

Figure 5. Surface and bottom temperature and DO levels in Santee River, South Carolina, during 1991

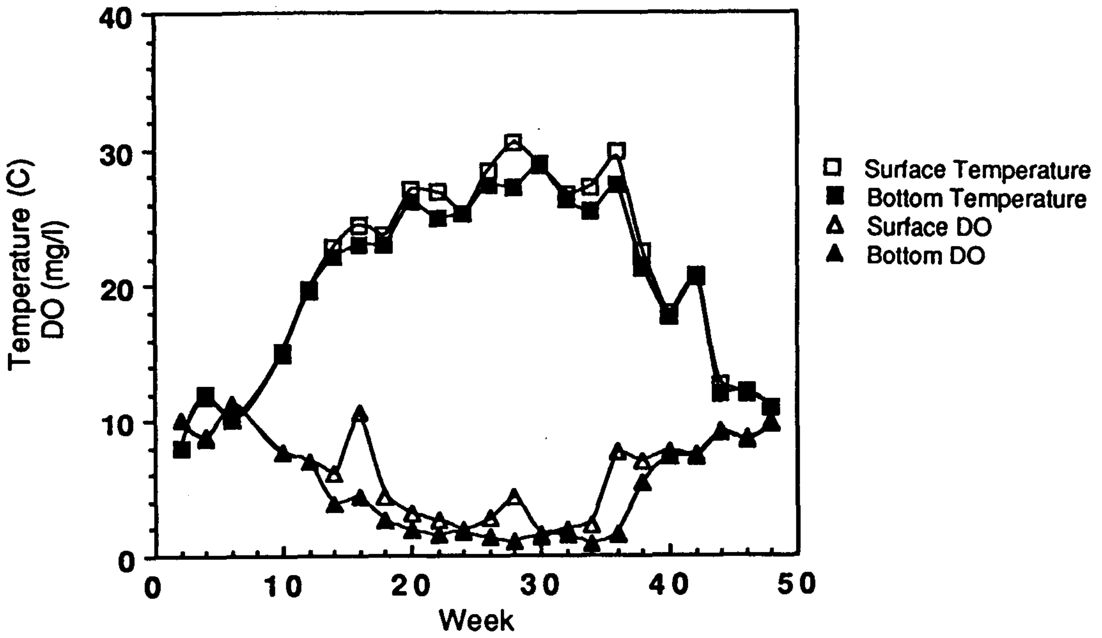

Figure 6. Surface and bottom temperature and DO levels at Elliot's Flats, Lake Marion, South Carolina, during 1991

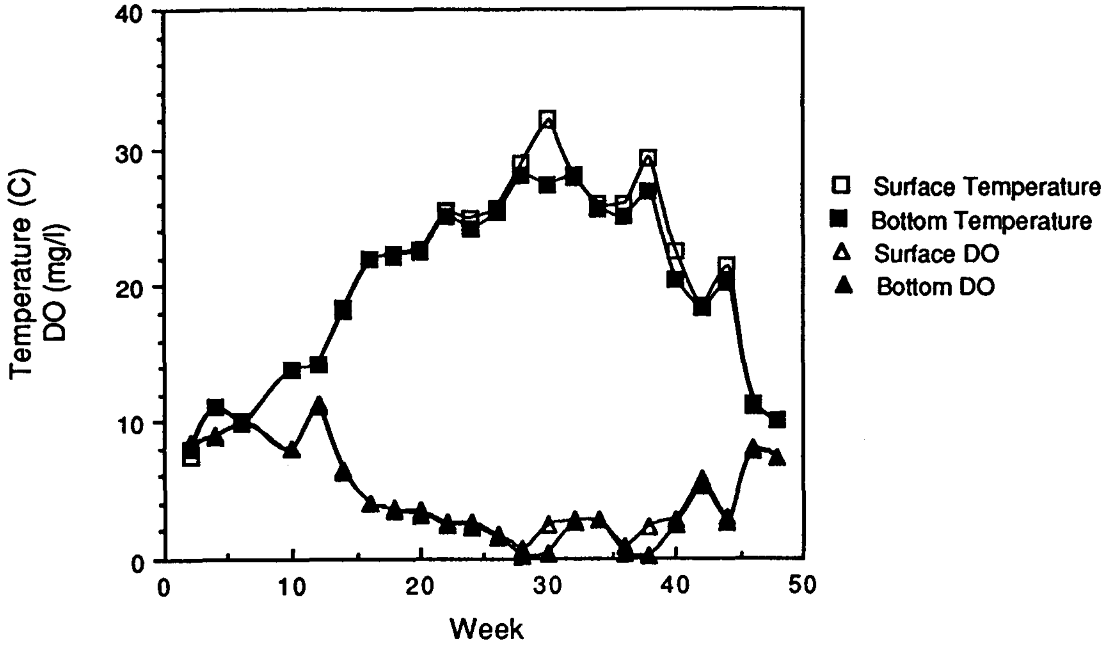

Figure 7. Surface and bottom temperature and DO levels at Sparkleberry Lake, Santee Swamp, South Carolina, during 1991

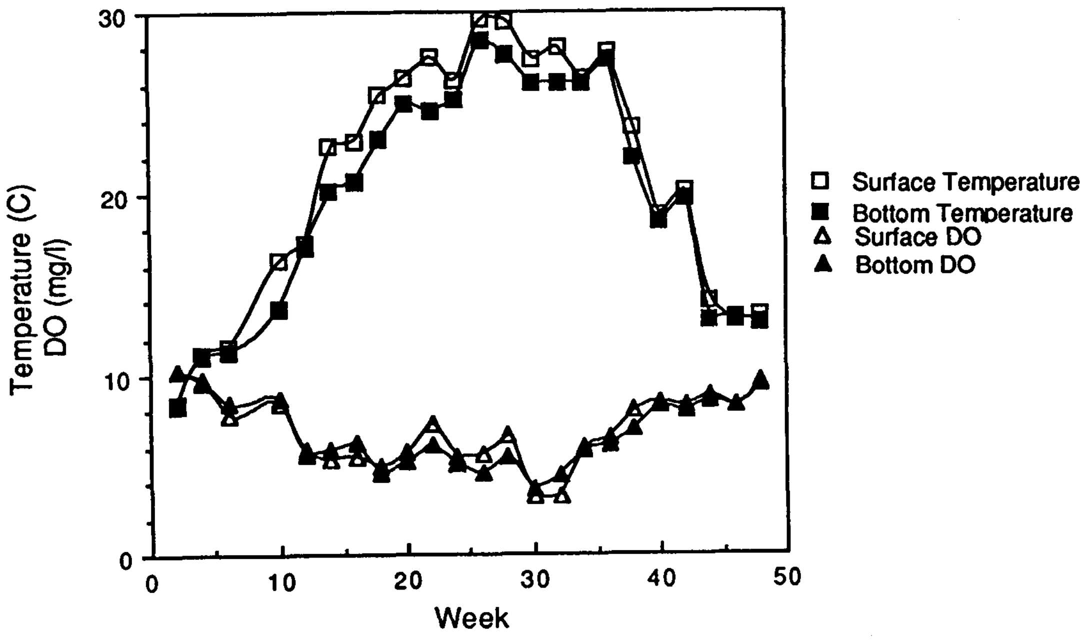

Figure 8. Surface and bottom temperature and DO levels at Brown's Lake, Lake Marion, South Carolina, during 1991

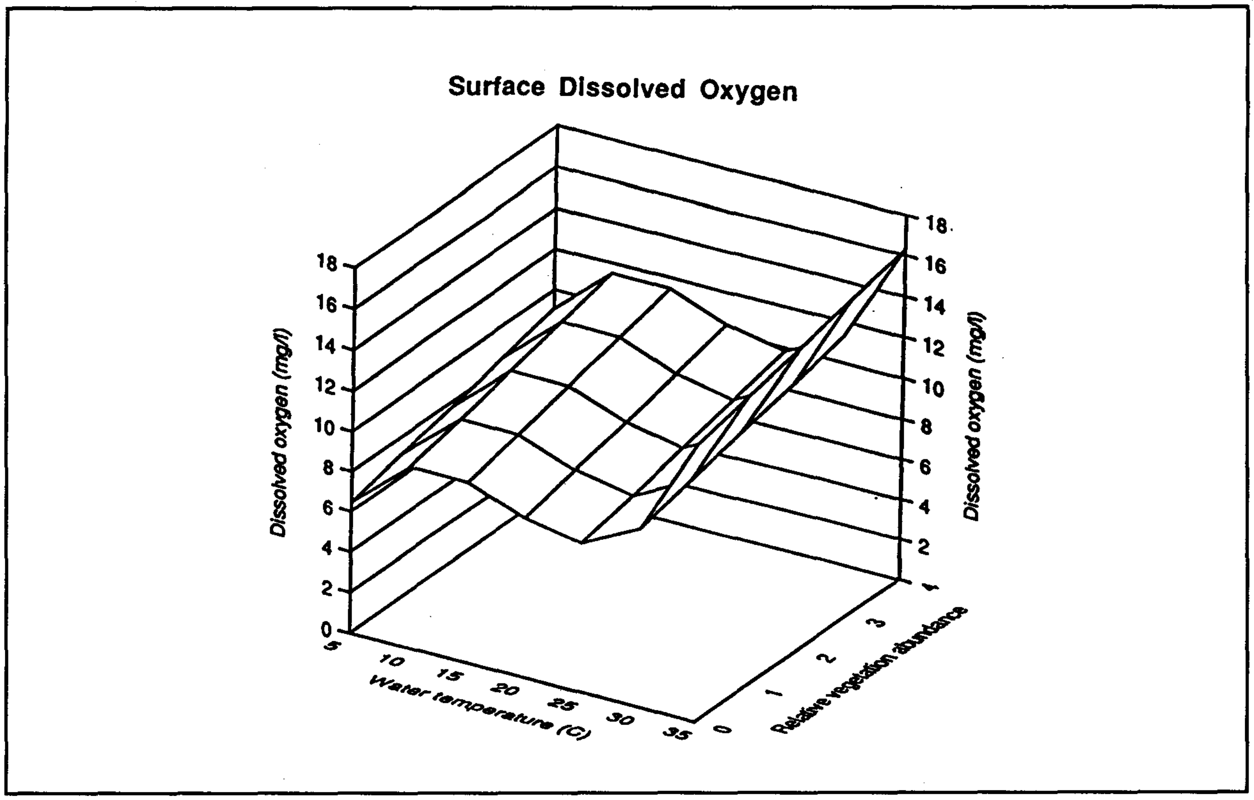

*Figure 9. Projected surface DO levels for four study areas in upper Lake Marion, South Carolina, during 1991. Surface DO = 1.786 * Surface temperature + 0.646 * Vegetation abundance - 0.115 * Surface temperature^2 + 0.002 * Surface temperature^3*

$p \leq 0.0001$) except Pack's Flats and Sparkleberry Lake ($p = 0.43$) and differed significantly between sampling periods ($F = 200.77$, $p \leq 0.0001$). The highest mean bottom DO level recorded was 11.3 mg/L at Pack's Flats on 19 February (week 6). The lowest mean bottom DO level recorded was 0.2 mg/L at Sparkleberry Lake on 11 July (week 26) and 17 September (week 36) and at Pack's Flats on 18 September (week 36). Bottom DO was related to bottom temperature and vegetation abundance (R-square = 0.93) (Figure 10). Bottom DO concentrations were relatively high at winter water temperatures and declined with increasing temperature, much like surface DO concentrations. Bottom DO concentrations continued to decline as vegetation abundance and bottom temperature increased.

Biweekly mean surface and bottom water temperatures were lowest during January. Temperatures increased throughout the year to a peak in July, August, and early September (weeks 26-36, Figures 4-8). After the summer peak, temperatures decreased throughout the remainder of the study period. Surface temperature differed significantly from bottom temperature for all areas ($t_{\text{Brown's Lake}} = 14.25$, $p \leq 0.0001$; $t_{\text{Elliot's Flats}} = 11.47$, $p \leq 0.0001$; $t_{\text{Pack's Flats}} = 12.20$, $p \leq 0.0001$; $t_{\text{Sparkleberry Lake}} = 8.04$, $p \leq 0.0001$; $t_{\text{Santee River}} = 6.29$, $p \leq 0.0001$).

Surface temperature differed significantly among all study areas ($F = 81.74$, $p \leq 0.0001$) except Brown's Lake (Figure 8) and Elliot's Flats ($p = 0.27$) and differed significantly among biweekly sampling periods ($F = 966.97$, $p \leq 0.0001$). The highest mean surface temperatures were recorded at Pack's Flats; 32.2 °C on 28 May (week 20); 32.5 °C on 11 July (week 26); 32.8 °C on 24 July (week 28) and 32.7 °C on 18 September (week 36). Lowest mean surface temperature recorded was 7.4 °C on 22 January (week 2) at Sparkleberry Lake. Pack's Flats and Santee River usually had the

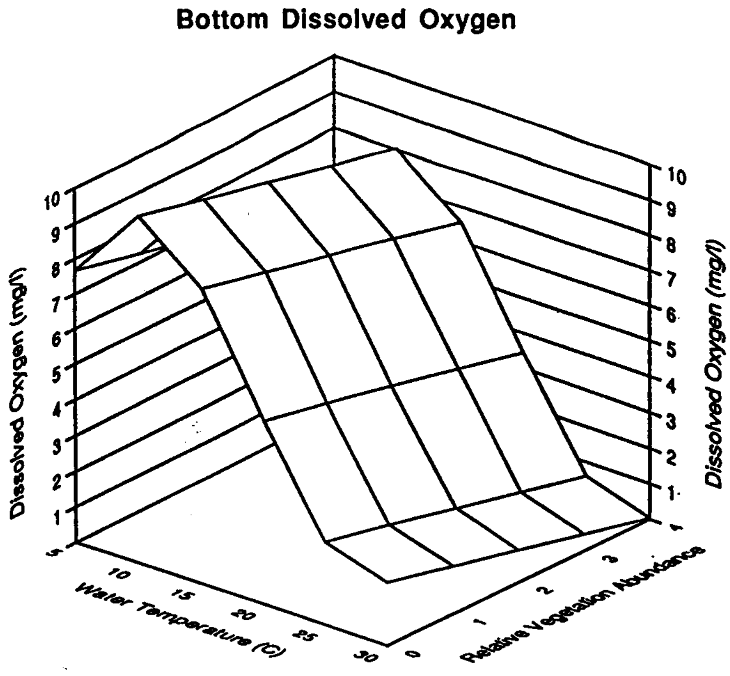

*Figure 10. Projected bottom DO levels for four study areas in upper Lake Marion, South Carolina, during 1991. Bottom DO = 2.224 * Bottom temperature - 0.448 * Vegetation abundance - 0.149 * Bottom temperature*^{2} *+ 0.003 * Bottom temperature*^{3}

highest and lowest surface temperatures, respectively.

Bottom temperatures were usually lower than surface temperatures. Santee River area usually had the lowest bottom temperatures of all study areas and showed the greatest fluctuations in bottom temperatures. Bottom temperature differed significantly among all study areas ($F = 13.33$, $p < 0.0001$) except Pack's Flats and Sparkleberry Lake ($p = 0.95$) and differed significantly between biweekly sampling periods ($F = 2015.89$, $p < 0.0001$). Highest mean bottom temperatures recorded were 28.8 °C at Pack's Flats and Elliot's Flats on 07 August (week 30) and 28.4 °C at Brown's Lake on 10 July (week 22). Lowest mean bottom temperatures recorded were 7.8 °C at Pack's Flats on 22 January (week 2) and 7.9 °C at Sparkleberry Lake on 23 January (week 2).

DO profiles and temperature profiles recorded on 17 September (week 36) showed the extent to which vegetation abundance influences the DO concentrations and temperature in the water column (Figure 11). Brown's Lake, which had the lowest vegetation abundance values, had uniform DO concentrations (6.5 mg/L at surface and 6.1 mg/L at bottom) throughout the water column. Temperatures at Brown's Lake were also uniform throughout the water column (27.8 °C at surface and 27.6 °C at bottom). In contrast, Pack's Flats, which had the highest vegetation abundance values, exhibited DO and temperature stratification. DO concentration and temperature declined from the surface (9.2 mg/L and 34.5 °C, respectively) to a depth of 30 cm (2.8 mg/L and 28.4 °C) and DO was very low (<1.0 mg/L) at the bottom. Elliot's Flats had relatively high vegetation abundance values and exhibited DO and temperature stratification, although not as extreme as Pack's Flats. Sparkleberry Lake had vegetation abundance values slightly higher than Brown's Lake and exhibited some stratification, but not nearly so much as Pack's Flats or Elliot's Flats. Triploid grass

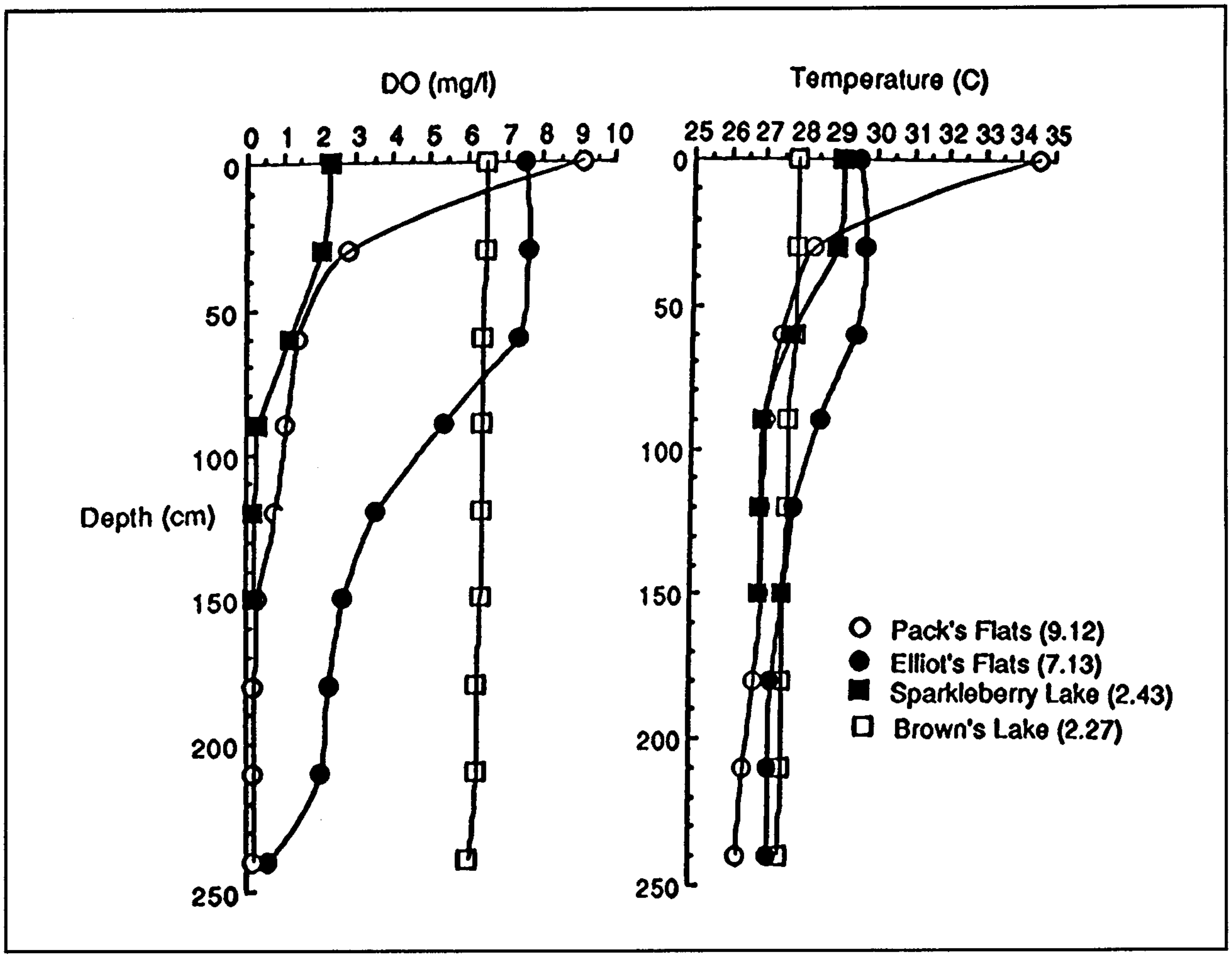

Figure 11. Temperature and DO profiles recorded on 17 September 1991 at four study areas in upper Lake Marion, South Carolina. Mean annual relative aquatic vegetation abundances reported in Figure 2 appear in parentheses

carp had achieved complete or near-complete control of aquatic vegetation in Elliot's Flats and Pack's Flats, respectively, by the summer of 1992. Temperature and DO profiles taken on 20 July 1992 and 29 July 1993 typify present summer conditions (Figures 12 and 13).

Discussion

Aquatic vegetation is a major problem for navigation and recreational activities in Lake Marion north of the I-95 bridge (Inabinette 1985). *Hydrilla* has been the most problematic species in Lake Marion in recent years. *Hydrilla* was the dominant vegetation species present in upper Lake Marion over the course of this study, regardless of season or water temperature. *Hydrilla* appeared to grow faster and form a surface canopy earlier in the year than any other species. This resulted in extensive, dense canopies of *Hydrilla* that shaded out other species of aquatic plants. Profound water quality impacts may occur when aquatic vegetation forms surface canopies over aquatic habitats, as *Hydrilla* did in upper Lake Marion. Buscemi (1958), Ultsch (1973), Schreiner (1980), and Frodge, Thomas, and Pauley (1990) described localized changes in water quality in ponds and lakes with patches of aquatic vegetation. Water quality characteristics in, under, or near plant beds was notably different from water quality characteristics in open-water areas. Physical and chemical characteristics of a vegetated area became more like characteristics of an open-water area when surface canopies of aquatic vegetation were physically removed (Frodge, Thomas, and Pauley 1990). Similar comparisons (between

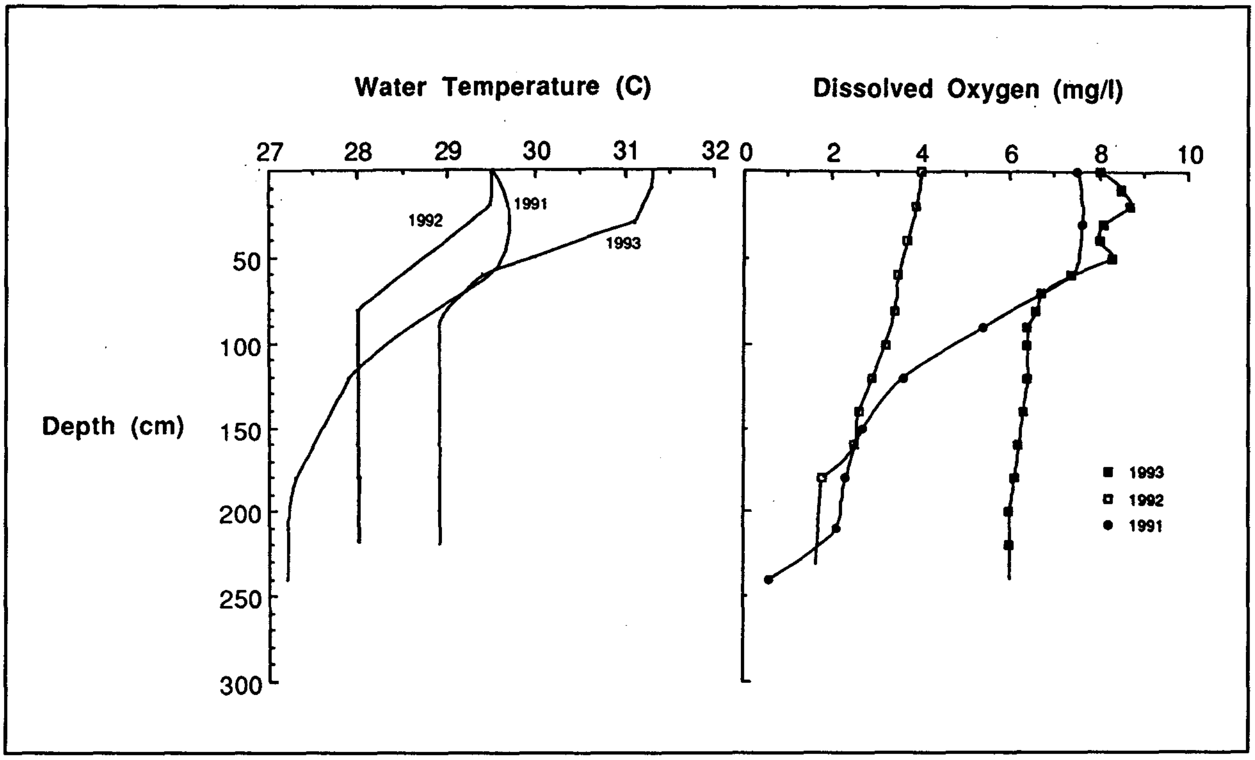

Figure 12. Summer temperature and DO profiles recorded at Elliot's Flats, upper Lake Marion, South Carolina

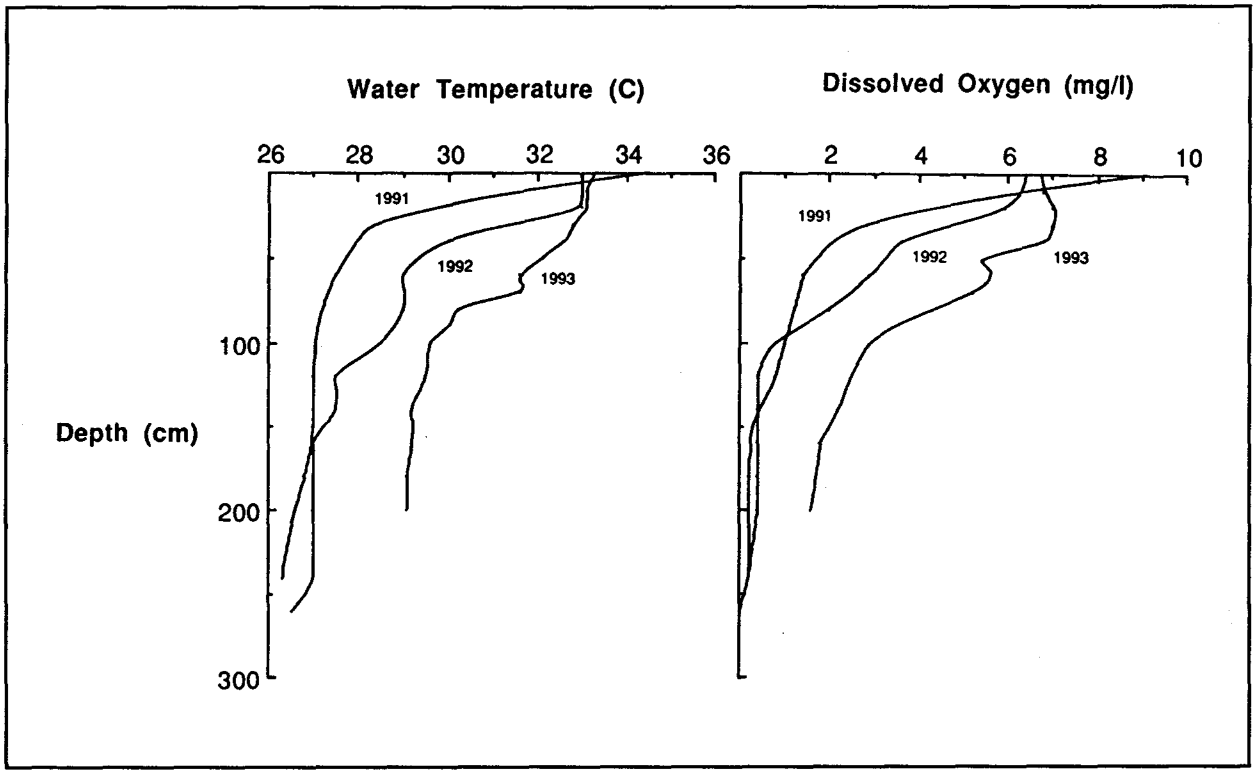

Figure 13. Summer temperature and DO profiles recorded at Pack's Flats, upper Lake Marion, South Carolina

vegetated and open-water areas) can be made in upper Lake Marion when heavily vegetated areas such as Pack's Flats are contrasted with less-infested areas such as Brown's Lake.

Areas of Lake Marion with dense growth of aquatic macrophytes (e.g., Pack's Flats and Elliot's Flats) exhibited distinctly different thermal characteristics from Brown's Lake, Sparkleberry Lake, and Santee River, where vegetation was sparse or absent. However, in winter when plant biomass was relatively low, thermal characteristics were similar for all study areas. Surface temperatures in vegetation canopies were very high (>30 °C) in Pack's Flats and Elliot's Flats during the summer months when canopies became extensive. Bottom temperatures were usually 5 to 10 °C lower than surface temperatures in these areas. In contrast, temperatures were more uniform throughout the water column at Brown's Lake, Sparkleberry Lake, and Santee River, where extensive surface canopies did not form. The extent of thermal stratification was apparently related to vegetation abundance. Thermal stratification was reported present in plant beds and absent in open-water areas by Rorslett, Berge, and Johansen (1986), Wylie and Jones (1987), and Frodge, Thomas, and Pauley (1990).

DO concentrations differed greatly from location to location in Pack's Flats and Elliot's Flats when dense surface canopies were present. This was probably because of limited horizontal mixing through dense growths of aquatic vegetation. DO concentrations as high as 15.0 mg/L were recorded in surface canopies. These supersaturated DO levels were similar to levels reported by Rorslett, Berge, and Johansen (1986), Wylie and Jones (1987) and Frodge, Thomas, and Pauley (1990). Supersaturation is apparently caused by photosynthetic activity by surface vegetation. Surface DO concentrations were related to vegetation abundance and water temperature (Figure 9). Winter surface DO levels were relatively low. Even though oxygen solubility is relatively high at winter water temperatures, photosynthetic activity by aquatic macrophytes and phytoplankton is low at winter temperatures and short photoperiod durations. The slight increase in surface DO levels as water temperatures increased from 5 to 10 °C was probably because of increased phytoplankton and macrophyte photosynthesis. In spring and early summer as water temperatures increased from 10 to 25 °C, the increased photosynthetic activity of macrophytes and phytoplankton was probably more than offset by the decreasing solubility of oxygen. As water temperatures increased above 25 °C and relative vegetation abundance increased, photosynthetic activity probably exceeded the effect of decreased oxygen solubility.

Bottom DO levels were lower beneath dense canopies of vegetation. Bottom DO levels were related to vegetation abundance and bottom temperatures (Figure 10). As water temperatures increased, oxygen solubility in water decreased. As vegetation abundance increased, the surface canopy became more dense, allowing less light to reach the bottom and thus decreasing photosynthetic activity at the bottom. Also, as the surface canopy becomes vertically thicker and more dense, some of the bottom layer of the surface canopy will die and fall to the bottom, thus increasing biological oxygen demand at or near the bottom. Subsurface oxygen depletion beneath canopies of aquatic macrophytes has been reported by Buscemi (1958), Wylie and Jones (1987), and Frodge, Thomas, and Pauley (1990).

The water quality conditions present in Elliot's Flats, Pack's Flats, and Sparkleberry Lake during summer present a problem for triploid grass carp. Although grass carp have low oxygen requirements (Opuszynski 1972), conditions present in these areas in the summer is probably not favorable for maximum feeding and growth rates. Chappelear (1990) reported a general downlake movement of triploid grass carp in upper Lake Marion during the summer of 1989. He hypothesized that this movement was due to low DO levels present in the uppermost areas of Lake Marion during the summer time. Triploid grass carp stocked downlake of Pack's Flats during 1990 generally remained in this area, with only a small percentage entering Pack's Flats (Kartalia 1992). Areas such as Pack's Flats, where water quality conditions are most extreme during the summer, do not provide suitable habitat for grass carp in the summer if a complete *Hydrilla* canopy exists. However, grass carp may enter these areas in fall, winter, and spring when water quality conditions are more favorable because aquatic vegetation is present year round. Complete or near-complete *Hydrilla* control and removal of a *Hydrilla* canopy has resulted in temperature and DO levels acceptable to triploid grass carp and native fishes.

There is no general consensus on the impact that reduction of aquatic macrophytes by grass carp has on fish communities (Carpenter and Lodge 1986). Removal of all aquatic vegetation in upper Lake Marion would reduce habitat variability and have an adverse effect on the fish community. However, this study indicates that a reduction of aquatic plant biomass in upper Lake Marion, in addition to improving recreational access, would improve water quality in Lake Marion. As a result of improved water quality, many areas would then be capable of supporting complex fish communities.

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