

Physical, Chemical and Biological Assessments of Selected TMDL Lakes in Lake, Polk and Sumter Counties

Sampled September 1998

December 1999

Environmental Assessment Section

Division of Resource Assessment and Management

Comprehensive Quality Assurance Plan No's:

Laboratories- 870346G & 870688G

Field- 980028

Executive Summary

FDEP's Bureau of Laboratories was requested to assess the status of selected lakes to determine if they should be on the 303(d) list by conducting habitat, water quality and biological monitoring of the lakes. Water bodies on the 303(d) list are required by EPA to have a Total Maximum Daily Load (TMDL) study conducted. The purpose of the TMDL is to determine the amount of pollution reduction needed to restore the system to a condition suitable for its designated use. For this study, three lakes in Central Florida were sampled to assess their status.

Nutrient enrichment in the form of total Kjeldahl nitrogen (TKN) was observed at Lakes Carlton and Deaton, and chlorophyll a at those two lakes also was elevated. Total phosphorus was elevated at Lake Lulu, and algal growth potential (AGP) at that lake was above the 5 mg dry wt/L "problem threshold". Turbidity values for Lakes Carlton and Deaton exceeded the values observed in 70% of other lakes in Florida. However, no exceedances of the State of Florida Class III criterion for turbidity of 29 NTU above background were observed. Total organic carbon (TOC) concentrations for all three lakes were elevated (18-25 mg/L).

Exceedance of the State of Florida Class III surface water quality criterion for dissolved oxygen occurred at Lake Lulu (3.9 mg/L).

Habitat assessment scores all were in the "suboptimal" range. Primary contributors to lowered habitat quality were low Secchi depths, "poor" bottom substrate diversity and "suboptimal" riparian zone alteration and upland land use scores.

It is recommended that Lakes Carlton and Lulu remain on the 303(d) list and that Lake Deaton be added to the 303(d) list.

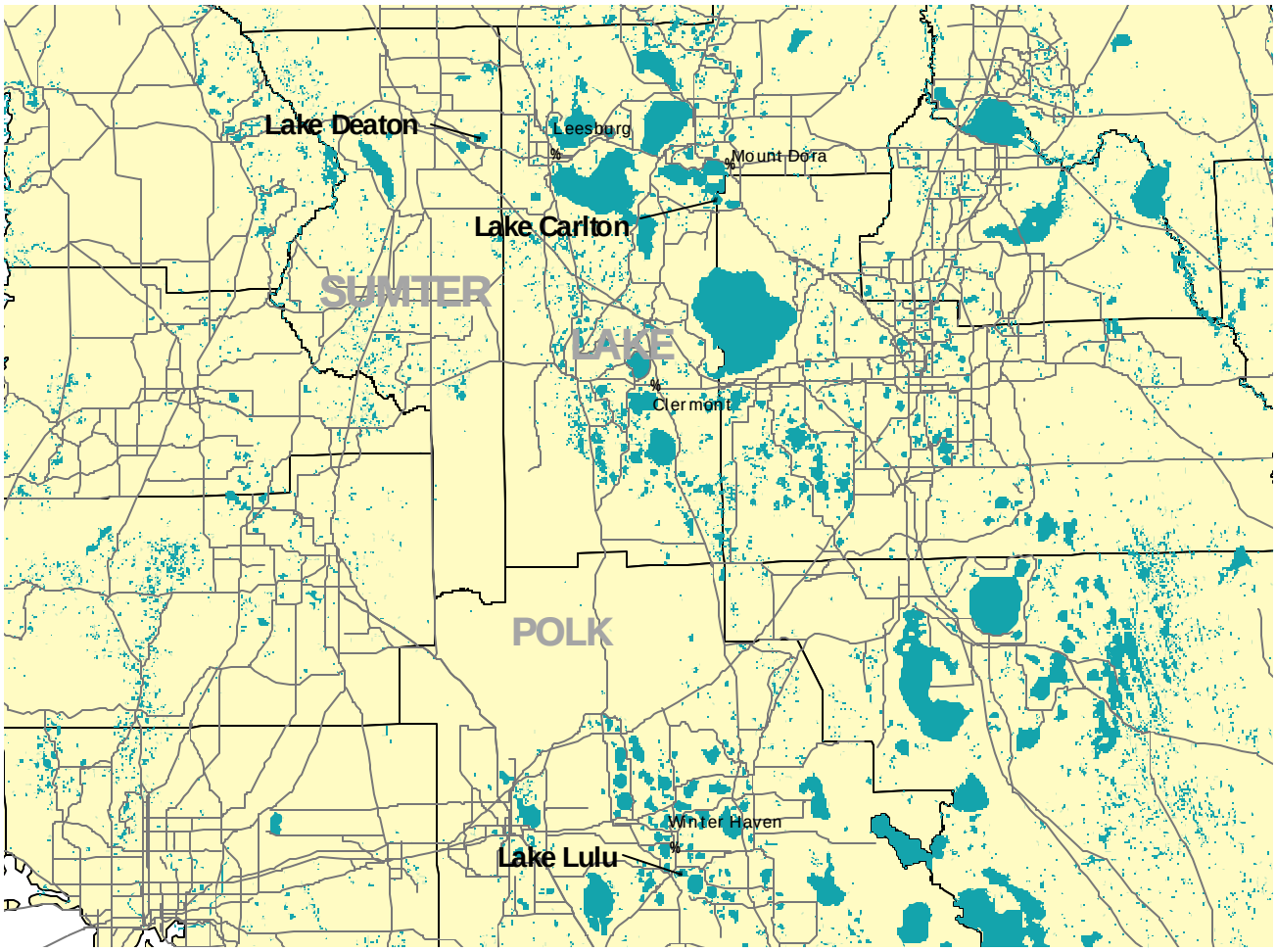


Figure 1: Overview Map

Introduction

The lakes from this study are located within Lake, Polk or Sumter Counties. Lake Carlton (Lake County) and Lake Deaton (Sumter County) both are located within the southern portion of the Central Valley area. The Central Valley area tends toward large, shallow, eutrophic lakes with abundant macrophytes or green algae. The southern lakes in this area often receive mineralized groundwater and surface water flows from nutrient rich soils, leading to eutrophic, hardwater lakes (Griffin et al., 1997). Predominant land use in the basins for Lakes Carlton and Deaton is agricultural. Lake Lulu (Polk County) is located within the Winter Haven/Lake Henry Ridges. This is an area of small to medium sized lakes which typically are characterized as alkaline, moderately hard water lakes of relatively high mineral content and which are eutrophic (Griffin et al., 1997). The Lake Lulu basin is comprised predominantly of residential and lake areas. Figure 1 shows the locations of the three lakes.

FDEP's Environmental Assessment Section was requested to assess the status of these three Central Florida lakes, two of which (Lakes Carlton and Lulu) were placed on the Total Maximum Daily Load (TMDL or 303(d)) list with limited data. Lake Deaton is not on the current 303(d) list. Prior to this assessment, the data available for these lakes consisted of less than 10 observations in the STORET database, somewhat dated, pre-1990 information, or qualitative non-point source survey data only.

Water bodies on the 303(d) list are required by EPA to have a TMDL study conducted to assess the quality of the water body with respect to chemical parameters and biological function. The purpose of the TMDL is to determine the amount of pollution reduction needed to restore the system to a condition suitable for its designated use. In this case, the designated use of each of the three Central Florida lakes of interest is for recreation and the maintenance of a healthy, well-balanced aquatic community.

Methods

The focus of this investigation was to determine if human activities are affecting the water quality or health of receiving water biota in Lakes Carlton, Deaton and Lulu, by collecting habitat, physical/chemical and biological information from the lakes. Sampling of the lakes was conducted on September 14, 1998.

A habitat assessment (FDEP, 1997a, Biology Section Standard Operating Procedure, BA-18) and physical/chemical characterization (FDEP 1997b, Biology Section Standard Operating Procedure, BA-17) were conducted at each lake site. Field measurements were conducted by FDEP Central Laboratory staff at each site for surface water dissolved oxygen (D.O.), pH and conductivity, with bottom, mid and surface depth horizons being measured for most sites. Water quality data in this report are from the mid-depth horizon, unless otherwise indicated. Surface water samples were collected from the center of each lake and analyzed in the FDEP Central Laboratory for nitrite-nitrate, total Kjeldahl nitrogen (TKN), total ammonia, total phosphorus (TP), total organic carbon (TOC), turbidity, total suspended solids (TSS), chlorophyll a, biochemical oxygen demand (BOD), algal growth potential (AGP), and color. Measurements also were conducted on each sample for fecal and total coliforms. Sediment collection and analysis were conducted to characterize sediment grain size and percent organic content.

Each of the three lakes also was sampled to determine the biological health of the systems. Benthic macroinvertebrate samples were collected at each site using a Petite PONAR sampler. For these samples, the 2-4m sublittoral zone of each site basin was divided into 12 equal segments, a grab was collected in each segment with the Petite PONAR sampler and combined into a single composite sample for each site, as described in FDEP, 1996. Each composite sample was randomly subsampled in the laboratory to a count of at least 100 organisms, which were identified to the lowest practical taxonomic level using a dissecting microscope.

Explanation of Measurements of Community Health

Selected measurements of community health were applied to assess each lake site. These measurements are briefly described here:

Habitat Assessment: Five attributes known to have potential effects on the lake biota were evaluated and scored at the site, with 20 points possible for each factor. The five attributes are: Submerged and Floating Vegetation Quality; Bottom Substrate Diversity; Riparian Zone Alterations; and Visible Upland Land Use. Overall habitat quality is assigned to one of four categories based on the sum of individual scores for those five attributes: Optimal (76-

100 Points); Suboptimal (51-75 points), Marginal (26-50 points); and Poor (0-25 points).

Taxa Richness: This measurement is based on the total number of macroinvertebrate taxa found at a site. Stress tends to reduce the number of different types of macroinvertebrates present in a system.

Numbers of pollution sensitive taxa: Some organisms become rare or absent as the intensity or duration of disturbance increases. The Hulbert Index assigns points to lake-dwelling macroinvertebrate taxa (0, 1 or 2) based on their sensitivity to pollution (Hulbert, 1990). A high score for the Hulbert Index typically is considered an indicator of good health for a waterbody.

Community structure: A system generally is considered degraded if a substantial shift in the proportions of the major taxonomic groups is observed. Increases in the percentage of dipteran organisms in a sample are indicative of poorer health of the system.

Ephemeroptera/Trichoptera/Odonata (ETO) Index: This index is expressed in two ways: as the sum of the number of ETO taxa present; and as the percentage of ETO organisms in the sample. This index is analogous to the Ephemeroptera/Plecoptera/Trichoptera Index used in stream systems. Higher numbers of ETO taxa and higher percentages of ETO organisms typically are associated with healthier systems.

Shannon-Weaver Diversity Index: This index is specified in the Florida Administrative Code as a measure of biological integrity. Low diversity values are undesirable, in that they represent conditions where only a few organisms are abundant, to the exclusion of other taxa. Such values may be associated with organic/nutrient enrichment and decreased dissolved oxygen.

Algal Biomass: The density of algal cells and the chlorophyll-a concentration of phytoplankton typically are used as estimators of biomass. A lake traditionally has been considered stressed when biomass exceeds problem threshold levels (e.g., approximately 20 mg/L of chlorophyll a), although far smaller increases in chlorophyll a may be among the first signs of trouble in a system. In this study, algal biomass estimates were based on chlorophyll a concentration of phytoplankton.

Descriptions of Study Sites

Lake Carlton covers an area of less than 100 acres. Upland land use in the Lake Carlton Outlet basin (1,469 acres) is predominantly agricultural according to 1988 land use information for St. John's River Water Management District. The lands directly bordering the lake are mainly residential with some recreational and agricultural areas. Lake Carlton currently is on the 303(d) list as a result of concerns about dissolved oxygen, nutrients and unionized ammonia in the Oklawaha River basin in which it is located.

Lake Deaton covers an area of approximately 550 acres. Land use in the Lake Deaton Outlet basin (6,615 acres) is predominantly agricultural (~75-80%) according to 1998 land use information for the Southwest Florida Water Management District (SWFWMD). Areas directly around the lake consist of wetlands bordered by agriculture to the north, east and west, and residential areas or wetlands bordered by residential, rangeland and upland forests to the south. Lake Deaton is not on the current 303(d) list, but was on the 1996 list because of concerns with nutrient concentrations based on limited pre-1990 data.

Lake Lulu is less than 100 acres in size. According to 1988 SWFWMD land use information, land use in the Lake Lulu

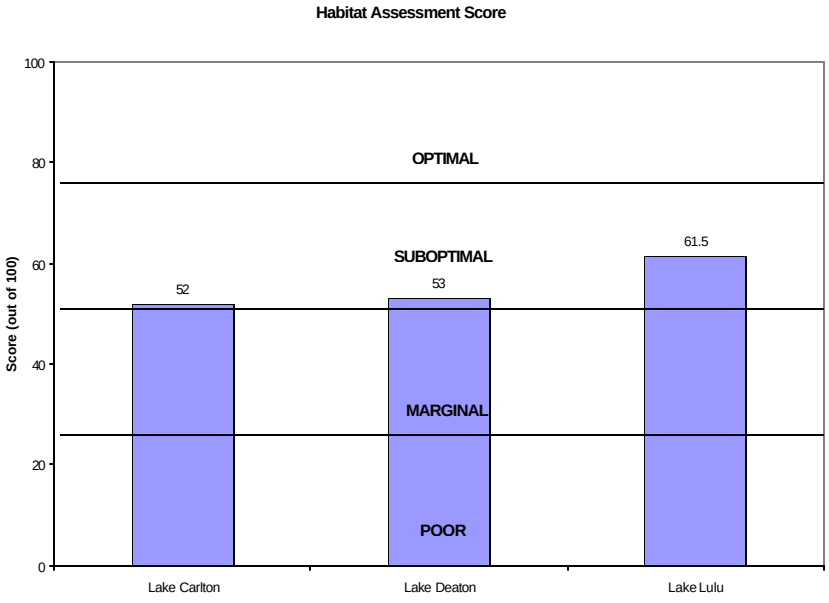


Figure 2: Habitat Assessment Score

Outlet basin (15,030 acres) is an equal mixture of predominantly residential and lake areas (approximately 75-80%), with commercial, industrial and agriculture comprising approximately 15-20%. Directly surrounding Lake Lulu, land use is industrial and commercial with some residential, open urban and upland forest areas. Lake Lulu currently is on the 303(d) list because of potential concerns with dissolved oxygen and nutrients in the Lake Lulu Outlet water segment of the Peace River basin.

Results and Discussion

Summary of Results by Site

The habitat assessment for Lake Carlton indicated overall "suboptimal" quality (52 points out of 100), with a "poor" score for Secchi depth and "suboptimal" scores for all other habitat assessment categories. Littoral zone emergent vegetation was dominated by macrophytes. Slight local watershed erosion was noted at the time of sampling, as well as a moderate potential for local watershed non point source (NPS) pollution. Water visibility was noted to be extremely reduced due to high color, with green algae and turbidity being observed. Lake Carlton exhibited elevated TKN (3.2 mg/L; higher than concentrations found in 90% of other Florida lakes; Table 1; refer to Appendix B, Typical Values for Selected Parameters in Florida Waters) and a very high chlorophyll a concentration (132 mg/L; higher than 95% of other Florida lakes). However, AGP was low (0.82 mg dry wt/L). Turbidity also was elevated (15 NTU; higher than 80% of other Florida lakes), although it was below the State of Florida Class III criterion, and TSS was 16 mg/L. Total ammonia was 0.034 mg/L for the lake, which is below the concentrations found in 40% of other Florida Lakes, and nitrate-nitrite was below the limit of detection (4 mg/L). TP, at 0.048 mg/L, also was below the concentrations found in 40% of other Florida lakes. Lake Carlton was alkaline (pH of 8.77 SU), and exhibited specific conductivity of 400 mmhos/cm2 and color of 140 PCU. While D.O. was good (7.54 mg/L), BOD was high (4.9 mg/L). The low percent of organic matter in the sediment (0.76%) for Lake Carlton does not suggest that it is a major factor in the BOD concentration. However TOC in the water sample was elevated (25 mg/L). Fecal and Total coliform levels were low (6 and 30 colonies/100 mL, respectively). It should be noted that the 6-hour holding time for bacteriological analyses was exceeded for all samples from Lakes Carlton, Deaton and Lulu. Sediment particle size was approximately equally sand to gravel (45%) and very fine sand (51%) with only a small fraction of silt/clay (3%). Macroinvertebrate measures yielded low values for several of the metrics of interest. However, recent information based on the development of a Florida Lake Condition Index indicates that macroinvertebrates are not useful indicators of biological condition in peninsular Florida lakes. More information on this finding and on the macroinvertebrate parameter values for Lakes Carlton, Deaton and Lulu is provided later in this report.

The habitat assessment for Lake Deaton indicated overall "suboptimal" quality (53 points out of 100), with "poor" scores for Secchi depth and bottom substrate diversity and a "suboptimal" score for visible upland land use. Trees were noted as the predominant littoral zone emergent vegetation at the sampling site. No local watershed erosion was observed at the time of sampling, and local watershed NPS pollution was noted to be slight. Water visibility was noted to be extremely reduced due to high color, with an additional notation of turbidity. With regard to water quality, Lake Deaton exhibited a good D.O.

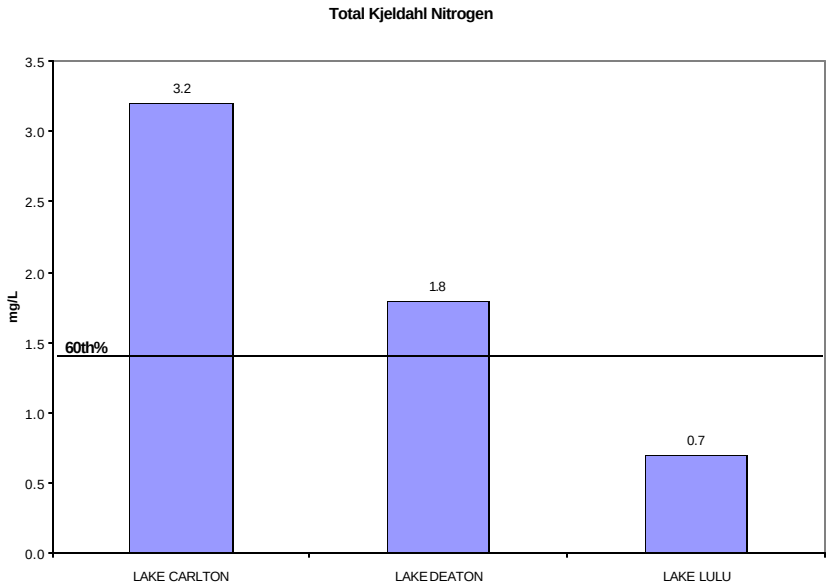


Figure 3: Total Kjeldahl Nitrogen

Table 1: Data Summary Table

Site	Lake Carlton	Lake Deaton	Lake Lulu
Storet Number	20020361	28500728159012	25020144
Sampling Date	9/14/1998	9/14/1998	9/14/1998
MACROINVERTEBRATE DATA:			
# Total Taxa	15	7	5
Hulbert Index	4	2	0
%Diptera	68	52	46
#ETO Taxa	0	0	0
%ETO	0	0	0
Shannon-Weaver Index	2.4	1.7	1.6
WATER QUALITY DATA:			
DO (mg/L)	7.54	7.70	3.90
pH (SU)	8.77 [a]	8.42 [a]	5.10
Cond (umhos/cm²)	400	170	57
Color (PCU)	140	60	200
BOD5 (mg/L)	4.9	3.3	1.1
Turbidity (NTU)	15	10 A	1.2
TSS (mg/L)	16	11 A	4 U
NO_2NO_3 (mg/L)	0.004 U	0.004 U	0.02 U
Ammonia (mg/L)	0.034	0.021	0.059
TKN	3.2	1.8	0.7
TP (mg/L)	0.048	0.025 I	0.24
TOC (mg/L)	25	18	18
Fecal Coliforms (#/100 mL)	6 Q	330 Q	1 KQ
Total Coliforms (#/100 mL)	30 Q	650 Q	10 Q
AGP (mg dry wt/L)	0.82 I	0.30 I	6.1 Q
ALGAL BIOMASS DATA:			
Chl-*a* (ug/L)	132	35.7	1 U
SEDIMENT DATA:			
Sand to Gravel (0.25 mm and greater)	45	40	9
Very Fine Sand (0.125 mm to 0.25 mm)	51	36	19
Silt/Clay Fraction (<0.063 mm to 0.125 mm)	3	24	72
Percent Organic	0.76	78.39	76.37
HABITAT ASSESSMENT DATA:			
Secchi Score	2	2	9
Submerged and Floating Veg Score	12	16	17
Bottom Substrate Diver Score	14	5	5.5
Riparian Zone Alterations Score	13	16	15
Visible Upland Land Use	11	14	15
Total Habitat Score	52	53	61.5

[a] Indicates field data are from upper sampling depth. All other field data are from mid-depth sampling.
A Indicates value reported is the mean of two or more determinations.
I Indicates value reported is between the method detection limit (MDL) and the practical quantitation limit (PQL).
K Indicates the actual value is known to be less than the value reported (actual value is off-scale low).
Q Indicates the sample was analyzed outside the holding time.
U Indicates parameter was not detected at or above this method detection limit.

concentration (7.7 mg/L), while BOD was 3.3 mg/L. Water column TOC was high (18 mg/L), as was percent organic content of the sediment (78%). The lake was alkaline (pH of 8.42 SU) with a specific conductivity of 170 mmhos/cm2 and color of 60 PCU. TKN was elevated in Lake Deaton (1.8 mg/L; higher than 80% of other Florida lakes), as was turbidity (10 NTU; higher than 70% of other Florida lakes), although the latter was below the State of Florida Class III criterion. Nitrate-nitrite was below the limit of detection (4 mg/L), and total ammonia (0.21 mg/L) and TP (0.025 mg/L) were lower than concentrations measured in the lower 30th percentile of other Florida lakes. AGP was low (0.3 mg dry wt/L), but chlorophyll a was elevated (35.7 mg/L; higher than 70% of other Florida lakes). Fecal and Total coliform counts (330 and 650 colonies/100 mL, respectively) were below the respective State of Florida Class III surface water criteria (800 colonies/100 mL and 2400 colonies/100 mL). Sediment particle size showed a good mix, with 40% sand to gravel, 36% very fine sand and 24% silt/clay fraction.

The Lake Lulu habitat assessment indicated overall "suboptimal" quality (61.5 points out of 100), with a "poor"/ "marginal" score for bottom substrate diversity, a "marginal" score for Secchi depth and "suboptimal" scores for riparian zone alterations and visible upland land use. Littoral zone emergent vegetation at the sampling site was noted as predominantly trees. No local watershed erosion was observed at the time of sampling, and local watershed NPS pollution was noted to be slight. Water visibility was observed to be extremely reduced due to high color, with the water being tannic but clear. Lake Lulu exhibited a D.O. concentration of 3.9 mg/L, which is below the State of Florida Class III criterion of 5 mg/L, but a BOD of only 1.1 mg/L. Although it is in an area said to be characterized by alkaline, hardwater lakes, Lake Lulu exhibited an acidic pH of 5.1 SU and a low specific conductance of 57 mmhos/cm2. Lake Lulu water was highly colored at 200 PCU. Turbidity (1.2 NTU) and TSS (undetected; <4 mg/L) both were low. At 0.7 mg/L, TKN was low relative to most other Florida lakes (lower 30%), and total ammonia was 0.059 mg/L (lower 50%). Nitrate-nitrite was not detected above an elevated detection limit of 0.02 mg/L. TP in Lake Lulu was quite high (0.24 mg/L), exceeding the 90th percentile concentration for all Florida Lakes. While chlorophyll a was undetected (<1 mg/L), AGP exceeded the "problem threshold" of 5 mg dry wt/L (Raschke and Schultz, 1987) at Lake Lulu (6.1 mg dry wt/L). It should be noted that the 72-hour holding time for AGP analysis was exceeded for the Lake Lulu sample. The potential effect of analyzing the sample outside the holding time would be a depression in the AGP result, since the test is a measure of the amount of bioavailable nutrients in a sample. TOC was elevated at 18 mg/L. Fecal and total coliform counts of 1 colony/100 mL and 10 colonies/100 m/L, respectively, were very low. The Lake Lulu sediments exhibited a high percent of organic content (76%), and sediment particles were predominantly silt/clay (72%), with 19% very fine sand and 9% sand to gravel fractions.

Macroinvertebrate Parameter Results

Macroinvertebrate community measures appear to be low for all three lakes sampled. However, recent information based on development of a composite Lake Condition Index (LCI), which ranks

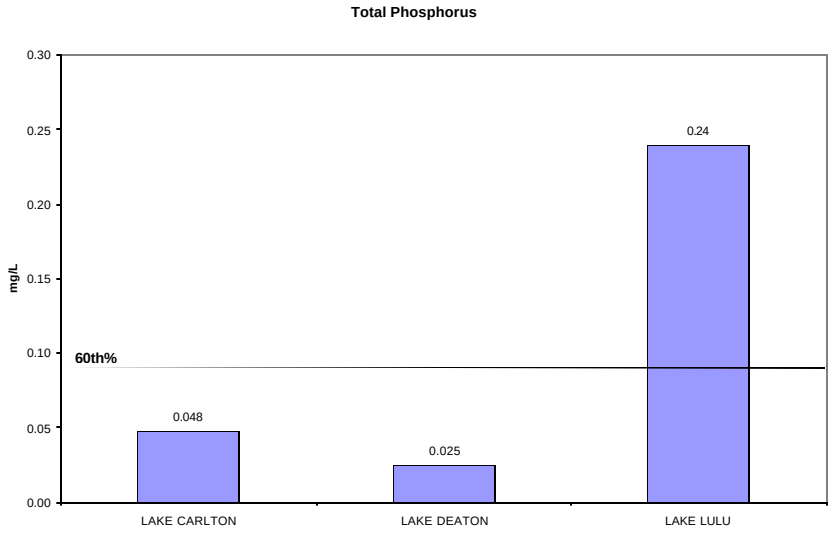


Figure 4: Total Phosphorus

a lake based on its attainment of ecoregional expectations, indicates that lake macroinvertebrate metrics for the Florida peninsular ecoregion (75) will be inconclusive. Reference and non-reference lakes from the Florida peninsula did not show a clear distinction when compared using the six metrics described previously, namely: taxa richness; Hulbert Index, % Diptera; #ETO taxa; %ETO; and Shannon-Weaver diversity. The conclusion was made that macroinvertebrates aren't sensitive biological indicators in the highly colored, organic rich lakes of Ecoregion 75 and it was recommended that they not be used as lake assessment tools for this ecoregion. All three lakes from this study are highly colored lakes located in Ecoregion 75. Therefore, while the macroinvertebrate metric values are summarized in this report (refer to Table 1), no definitive conclusions regarding biological condition can be drawn from those data at this time.

Conclusions

Nutrient enrichment in the form of TKN was observed at Lake Carlton and Lake Deaton in concentrations above those observed in 80% to 90% of other Florida lakes. Chlorophyll a at those two lakes also was elevated, with Lake Deaton exceeding the concentration observed in 70% of other Florida lakes and Lake Carlton exceeding the concentrations observed in 95% of other Florida lakes. Total phosphorus was elevated at Lake Lulu, exceeding the concentrations observed in 90% of other Florida Lakes. AGP at Lake Lulu was above the 5 mg dry wt/L "problem threshold". Turbidity values for Lakes Carlton and Deaton exceeded the values observed in 70% of other lakes in Florida. However, no exceedances of the State of Florida Class III criterion for turbidity of 29 NTU above background were observed. TOC concentrations for all three lakes were elevated (18-25 mg/L).

Exceedance of State of Florida Class III surface water quality criterion for dissolved oxygen occurred at Lake Lulu (3.9 mg/L).

Habitat assessment scores all were in the "suboptimal" range. Primary contributors to lowered habitat quality were low Secchi depths, "poor" bottom substrate diversity and "suboptimal" riparian zone alterations and upland land use.

Initial specific reasons for two of these three lakes being on the current 303(d) list include potential concerns about dissolved oxygen, nutrients and unionized ammonia for Lake Carlton, and dissolved oxygen and nutrients for Lake Lulu. Dissolved oxygen and unionized ammonia do not appear to be issues of

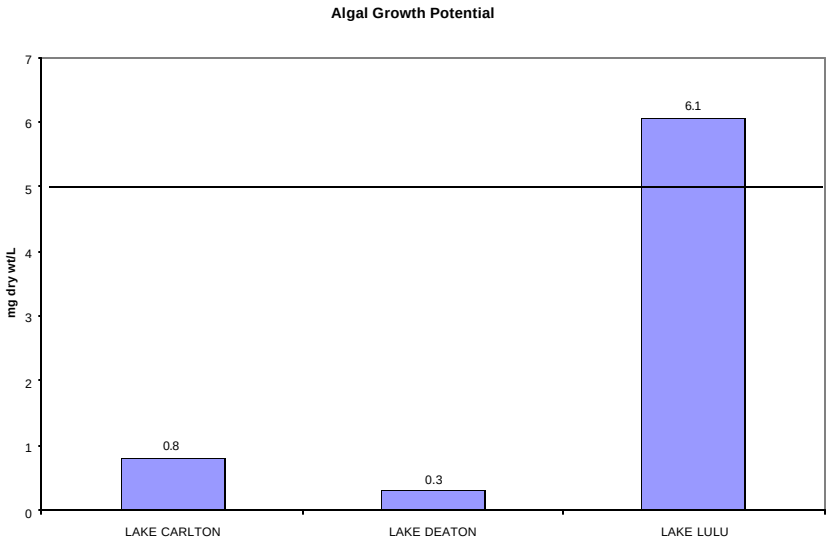


Figure 5: Algal Growth Potential

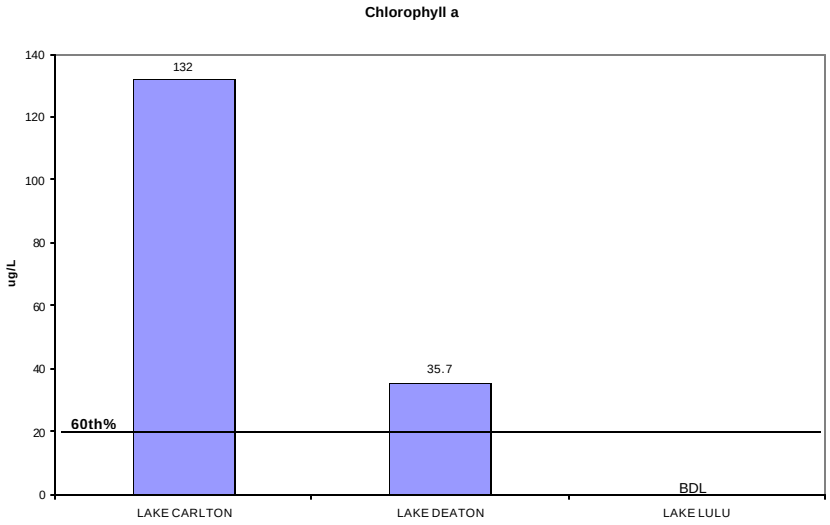


Figure 6: Chlorophyll a

concern for Lake Carlton, based on the recent sampling. However, the data collected in September, 1998, do indicate concerns with nutrients and other water quality parameters at Lakes Carlton, Deaton and Lulu, as described in this report.

The assessment of lake condition will be more meaningful when biological indicators are used in conjunction with physical/chemical measurements. There are plans to develop biological indices for phytoplankton and aquatic macrophytes for use as assessment tools for lake condition. Such indices are particularly needed for areas like Ecoregion 75, where macroinvertebrate measures have been judged not to be useful. In the meantime, on the basis of the physical/chemical and algal biomass data collected in September 1998, it is recommended that Lakes Carlton and Lulu remain on the 303(d) list and that Lake Deaton be added to the 303(d) list.

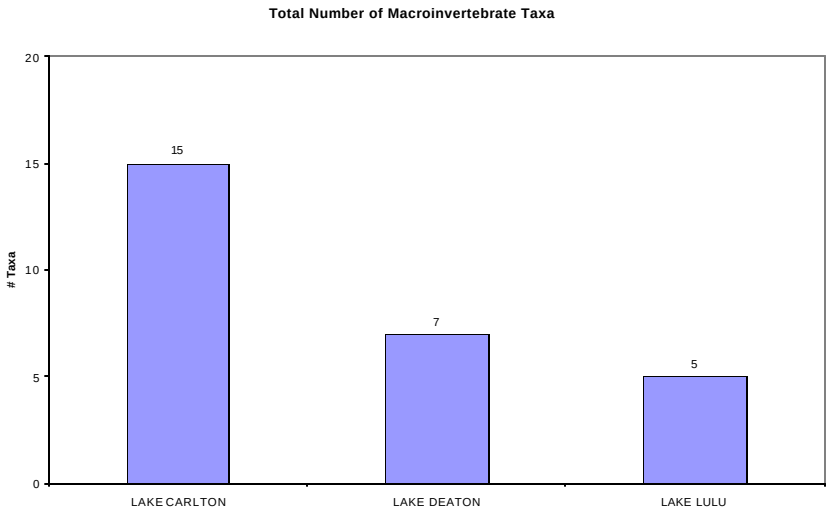


Figure 7: Total Number of Macroinvertebrate Taxa

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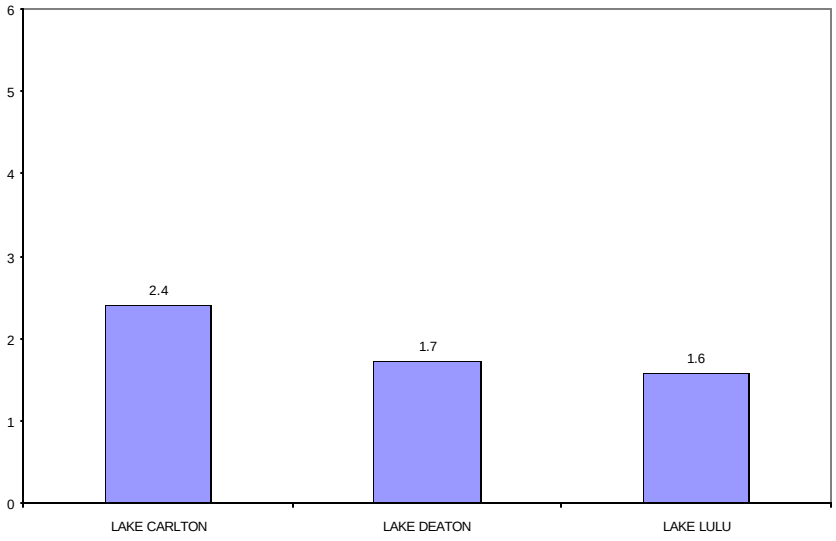
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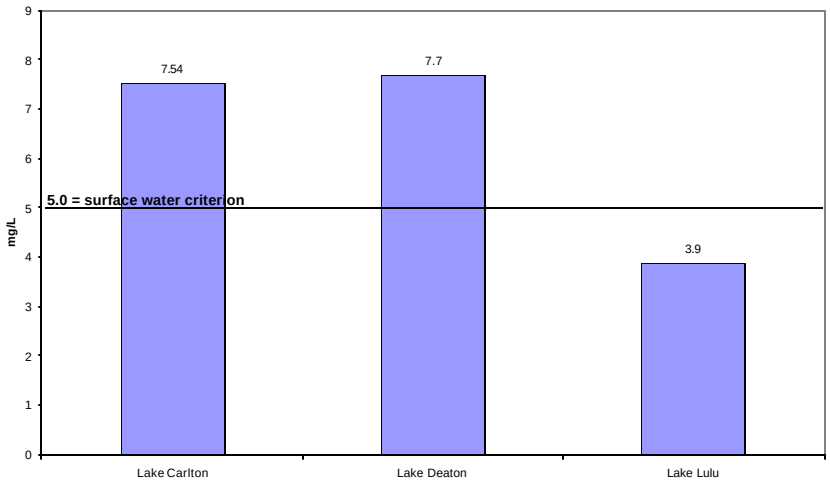
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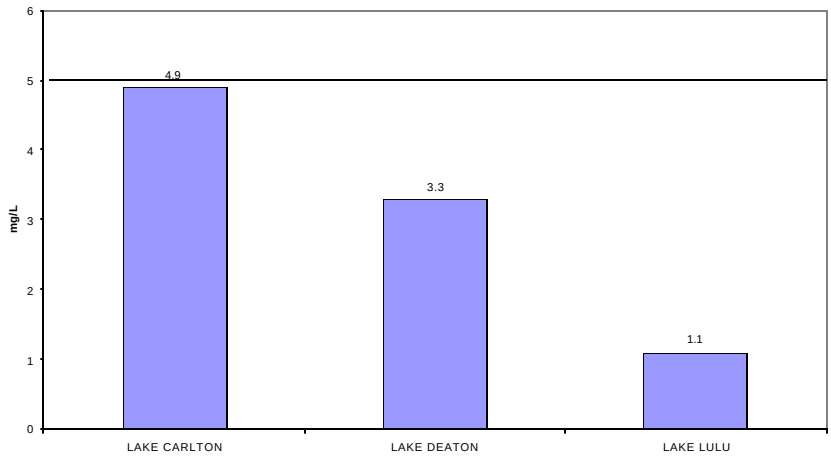
Shannon-Weaver Diversity Index



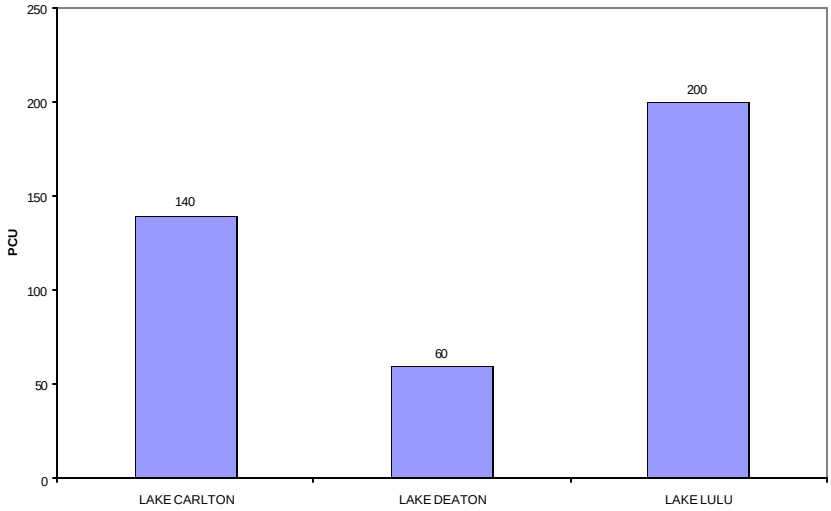
Dissolved Oxygen



Biochemical Oxygen Demand



Color



Turbidity

