Interaction of light, nutrients and phytoplankton in a black-water river, St. Johns River, Florida

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Nutrient enrichment bioassays, water chemistry, primary productivity and spectral absorption measurements of the water column were assessed monthly at three stations in the lower St. Johns River. The bioassays and the water chemistry indicated phytoplankton standing crop was not limited by nitrogen or phosphorus for any date or station. Phytoplankton growth in the control treatments of the nutrient enrichment bioassays and the productivity vs. irradiance data indicated the phytoplankton community to be predominantly light limited. The shallow profiles of the P vs. I curves were indicative of shade adapted algae. Maximum productivity was found at less than 0.25 m depth in a five-m water column. Productivity was seasonally influenced with the greatest productivity in the summer and the lowest in the winter months. The most important factors controlling primary productivity in this river appears to be light attenuation due to the high water color and compensatory low-light adaptation by the phytoplankton.

Citizens Advocacy - Lake Apopka

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We intend to explore and try to understand some cause and effect relationships between the Friends of Lake Apopka (FOLA), a citizens advocacy group, and the restoration of Lake Apopka. When FOLA was formed in late 1991 - early 1992, the general situation could be described as follows: 1) The Zellwood Drainage and Water Control District (ZDD) was discharging 15 billion gallons of water and in excess of 100,000 pounds of phosphorus annually into Lake Apopka. ZDD had negotiated a ten-year Consent Order that would gradually reduce phosphorus discharges to about 41,000 pounds, but allow these discharges to continue at least until the year 2001. 2) The two principal parties, SJRWMD and ZDD as institutions and personalities were adversaries, having gone through difficult negotiations and legal battles. 3) After thirty years of continuous algal bloom, the public and politicians perceived Lake Apopka as a hopeless case. The lake had been studied both frequently and extensively. Since no tangible improvement had been made, the layman's consensus was that Lake Apopka cannot be cleaned up. 4) The local economy was depressed.

FOLA represents the community, the public. What we are about is ADVOCACY -- EDUCATION -- PERSUASION -- COST BENEFIT ECONOMICS -- PRIORITIES

AND TRADEOFFS -- NEGOTIATIONS -- PUBLIC RELATIONS. Our goal is to restore Lake Apopka. Our task is essentially to change the long-standing STATUS QUO. The bottom line is that it is permitted and legal for the muck farmers to pollute Lake Apopka on a massive and continuing basis at least until the year 2001. The grandfathered rights of the farmers of the last 50 years conflict directly with rights of the public and other property owners to have a healthy Lake Apopka, Harris Chain, and Ocklawaha River Basin.

FOLA has
- Helped set priorities. Focus on farm discharges, versus other ongoing projects.
- Involved politicians. Politicians get involved because voters, not agencies, are their clients.
- Represented other economic interests besides farmers.
- Been pragmatic. Problem solving as opposed to who pays the costs of clean up.
- Built consensus. Involved a broad spectrum of the community.
- Educated the community. Information on legalities, realities, trade-offs, and what is possible.
- Been a volunteer organization. No organizational ego. Fluid and flexible. Basic common sense.
- Represented the public. Spending of taxpayer dollars. Make some regulation acceptable in an anti-regulation environment.

Consumptive use permitting in SWFWMD

Becky Ayesh (Environmental Confederation of Southwest Florida, 421 Verna Lane, Sarasota, Florida 34240)

The Southwest Florida Water Management District issues water use permits for surface and groundwater withdrawals under Chapter 40D-2, Florida Administrative Code.

In order to obtain a Water Use Permit, an Applicant must demonstrate that the water use is reasonable and beneficial, is in the public interest, and will not interfere with any existing legal use of water, by providing reasonable assurances, on both a individual and a cumulative basis, that the water use meets the Conditions for Issuance of Permits (40D-2.301, F.A.C.).

The following Conditions for Issuance are of particular interest for the management of lakes:

(b) Will not cause quantity or quality changes which adversely impact the water resources, including both surface and ground waters;

(c) Will not cause adverse environmental impacts to wetlands, lakes, streams, estuaries, fish and wildlife, or other natural resources;

(d) Will not cause water levels or rates of flow to deviate from the ranges set forth in Chapter 40D-8;

(h) Will not adversely impact offsite land uses existing at the time of application.

Each of the above conditions has a "performance standard" established by the District which would accomplish the goal of the condition.

The environmental performance standards for lakes are:

Water levels in lakes shall not deviate from normal rate and range of fluctuation, to the extent that:

a. Water quality, vegetation, or animal populations are adversely impacted;

b. Flows to down gradient watercourses are adversely impacted; and/or

c. Recreational use or aesthetic qualities of the water resources are adversely impacted.

The District has developed presumptions to facilitate evaluation of whether a water use meets the Conditions for Issuance or performance standards.

The following are the environmental presumptions for lakes:

a. The District presumes that a surface water withdrawal will not cause unacceptable environmental impacts if the total annual withdrawal, combined with other surface withdraws, does not exceed the volume contained within the top foot of water at average lake area.

b. The District presumes that a surface water withdrawal will not cause unacceptable environmental impacts if the withdrawal of water, combined with other surface withdrawals, does not exceed a rate of one-quarter inch per day over a 30 day period. A quarter inch lowering shall be equivalent to the volume contained in the top quarter inch of water at average lake area.

c. The District presumes that a ground-water withdrawal will not cause unacceptable environmental impacts if the withdrawal of water, combined with other ground-water withdrawals, does not lower the water table at the lake by more than 1 foot.

The District does not add groundwater drawdowns to surface water drawdowns to ascertain if there is a combined drawdown exceeding 1 foot.

In 1995, the presumptions used by the District for evaluation of Water Use Permits were part of a Rule Challenge.

The Recommended Final Order is due in March for all parties. The Hearing Office is expected to rule sometime this summer.

A synopsis of the Final Orders will be presented at the annual meeting.

Relations Between Trophic State Indicators and Fish in Florida Lakes

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Total fish biomass per unit area was positively correlated with total phosphorus, total nitrogen, chlorophyll a, and inversely correlated with Secchi disk transparency in 65 Florida lakes selected to range from oligotrophic to hypereutrophic. Species numbers were positively related to lake surface area but not trophic state. Of the 65 species collected only 5, the lake chubsucker (*Erimyzon sucetta*), golden

topminnow (*Fundulus chrysotus*), lined topminnow (*Fundulus lineolatus*), redfin pickerel (*Esox americanus americanus*), and Everglades pygmy sunfish (*Elassoma evergladei*) showed decreases in frequency of occurrence with increasing trophic state; all other species either stayed the same or increased in frequency of occurrence as lakes became more eutrophic. Most species showed no significant change in standing crop with changes in trophic state, while one species, the warmouth (*Lepomis gulosus*), decreased and five species, the gizzard shad (*Dorosoma cepedianum*), threadfin shad (*Dorosoma petenense*), black crappie (*Pomoxis nigromaculatus*), redear sunfish (*Lepomis microlophus*), and blue tilapia (*Tilapia aurea*) showed increases in standing crops with increasing trophic state. The facts that Florida lakes do not have deep, cold hypolimnia, do not have salmonid species, and have no ice in the winter are among the possible reasons that eutrophication of Florida lakes does not cause the same changes in fish populations often described for northern lakes.

A New Look at Lake Apopka: How it works

Roger W. Bachmann and Daniel E. Canfield, Jr (Department of Fisheries and Aquatic Sciences, University of Florida, Gainesville, FL, 32653, (352) 392-9617ext 251, e-mail rbach@nervm.nerdc.ufl.edu)

A new analysis of data collected during past studies on Lake Apopka reveals that it does not function like other lakes. Previous investigators had assumed that algal production driven by external phosphorus loads was the only important source of organic carbon in the lake. It was further believed that not all of the algal-derived organic carbon was consumed by the food chain organisms or decomposers, so that there was an annual surplus of organic carbon being deposited as a flocculent sediment on top of a layer of previously deposited consolidated sediments on the lake bed. This resulted in the addition of 22 cm of unconsolidated flucculent sediments between 1968 and 1987.

Our reanalysis of past data produced two new findings. 1) The lake mean depth decreased by only 3 cm between 1968 and 1987, not 22 cm. 2) On an average day more organic carbon is biologically decomposed by respiration in the water column than is formed by the plankton algae in primary production.

The most logical interpretation of these data is that the consolidated sediments previously protected from wave action by the macrophyte beds prior to the 1947 hurricane are now being eroded by water movements and are being converted to flocculent sediments. Between 1968 and 1987 19 cm of previously consolidated sediments were converted to unconsolidated sediments due to wave-driven turbulence. During resuspension some of the sediment organic matter is oxidized in the water column probably driving a heterotrophic branch of the food chain and releasing nutrients previously tied up in sediment organic matter. In other words Lake Apopka is a heterotrophic system. It is not depositing organic matter but is

consuming old organic matter. We know of no other lake reported in the scientific literature that functions like this.

The implications of these findings to the restoration of Lake Apopka will be discussed.

Lake Holden: A Case Study of a Successful Lakefront Homeowner's Association

Richard A. Baird (Orange County Environmental Protection Department, 2002 E. Michigan Street, Orlando, FL 328)

Lakefront homeowner's groups across the state and nation are struggling with the effects of past and present government policies that have left their lakes either choked with aquatic weeds or clouded with planktonic algae, or in some cases both. Some of these groups expect the government to fix their lake, others have given up hope of ever improving their lake's water quality and recreational uses. Others, like Lake Holden, have organized into groups and utilized special funding mechanisms to tax themselves to provide seed money for actual construction of stormwater abatement projects and grants. Lake Holden has created a municipal service taxing unit (MSTU) to generate money independent of County general fund revenues. They have initiated a basin wide water quality study, purchased land for retention ponds and obtained a grant from the Florida Department of Environmental Protection (FDEP). This paper chronicles the history, organization, programs, events, projects, problems and successes of the Lake Holden lakefront homeowner's efforts over the past twenty years.

Evaluation of the effects of nutrient removal and the "Storm of the Century" on submersed vegetation in Kings Bay - Crystal River, Florida.

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Municipal wastewater effluent was removed in 1992 from a cove (Cedar Cove) of Kings Bay in an attempt to reduce the bay's ambient total phosphorus (TP) and total nitrogen (TN) concentrations. Many citizens and professionals viewed nutrient removal as the solution to reducing the bay's nuisance growths of aquatic macrophytes and filamentous algae. Wastewater removal reduced average TP from 105 $\mu g \cdot L^{-1}$ to 27 $\mu g \cdot L^{-1}$ and average TN from 620 $\mu g \cdot L^{-1}$ to 220 $\mu g \cdot L^{-1}$ in Cedar Cove. TP (24 $\mu g \cdot L^{-1}$ to 28 $\mu g \cdot L^{-1}$) and TN (300 $\mu g \cdot L^{-1}$ to 260 $\mu g \cdot L^{-1}$), however, were not significantly reduced in southern Kings Bay. There were no significant changes in average frequency of occurrence of Vallisneria in Cedar Cove (0% to 1%) or southern Kings Bay (19% to 22%). Average hydrilla occurrence decreased significantly after wastewater removal in Cedar Cove (54% to 36%) and southern

Kings Bay (61% and 35%). Eurasian watermilfoil occurrence significantly increased in Cedar Cove (6% to 24%) and southern Kings Bay (11% to 32%). Filamentous algal occurrence in Cedar Cove averaged 34% prior to and 40% after wastewater removal. In southern Kings Bay, the frequencies of occurrence averaged 5% and 2%, respectively. If removal of Crystal River's wastewater discharge was responsible for the differences detected in plant abundances, the same reductions/increases in species abundance should not occur in Cedar Cove as in southern Kings Bay. Significant changes in plant occurrence were attributed to the March 13, 1993 "Storm of the Century", not to the removal of wastewater. Further nutrient control is not recommended as an option for reducing nuisance growths of submersed aquatic vegetation in Kings Bay-Crystal River, Florida.

Are You in Charge of the Lakes?" - Responsibility at the Local Level

Mike Britt (P. E., Lakes Manager City of Winter Haven 550 7th Street, S. W., Winter Haven, Florida 33880, (941) 291-5850)

This paper and talk will present the perspective of a smaller local government in the lakes management decision-making process. Given limited resources and expertise, lakes management decisions at the local level are frequently based on general knowledge and methodologies, what is acceptable on a political level (whether local funds may be available), and whether outside funding assistance may be available for a specific idea. In some instances, little or no scientific information or guidance is available for solutions to lake management problems. Winter Haven is a municipality of 25,000 people with 30 lakes inside the City limits. Lakes cover approximately 32% of the city with over 20% of the population living either on or near a lake. The City works with numerous state, regional and other local governmental agencies for the improvement of lake resources. Numerous processes exist at numerous levels for making decisions. Citizen committees, advocacy groups, peer review, political accountability, and other state and regional groups all play a role in making local decisions. It is well understood that the lakes are a state resource, however, decisions on lake management programs are almost always originated at the local level. A closer relationship with the problems and the need for more accountability to citizens sparks an action approach to solving perceived lake management problems. Personnel at higher levels of government are frequently placed in the reactive position of responding to local ideas and requests, and are reluctant to take a proactive approach to solving problems. Also, this paper will explore the various programs and responsibilities of local lakes management agencies.

Fish community response to lake eutrophication-a case study

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The objective of this study was to measure changes in fish community biomass and structure from 1970 through 1995 at Lake Tarpon, Florida. Fish were utilized as ecological indicators of changing lake productivity as water quality data are incomplete over this period. Lake Tarpon (1,030-ha) is located in densely-populated Pinellas County within the Tampa Bay metropolitan area. Urban development of the lake drainage basin was sparse until the mid-1970s and over the past 20 years development has impacted 40% of the basin. Since 1970, fish biomass estimates were obtained by shoreline blocknet sampling with rotenone. Biomass estimates from 1970 and 1982 varied between 18 to 61 kg/ha. Fish biomass indicated significant increases in productivity after 1982. Estimates during 1987 increased to 134 kg/ha and by 1995, biomass was estimated at 614 kg/ha. Fish community structure indices from 1970 to 1995 were indicative of well balanced populations dominated by sport fish species. Water quality data indicated mesotrophy since 1970; however, significant changes in trophic state were not indicated through 1995. Fish community analysis may be more sensitive detecting cultural eutrophication than water quality data. Earlier detection can lead to implementation of abatement measures before more-expensive restoration is required.

Sturgeon in Florida: a dilemma in conservation efforts

Frank A. Chapman (Department of Fisheries and Aquatic Sciences, University of Florida, 7922 N. W. 71 St Street, Gainesville, FL 32653)

Sturgeon represented an important commercial fishery in Florida. The fish commanded high market acceptability for its excellent quality of flesh for smoking and roe for making caviar. The sturgeon fishery dramatically declined, early at the turn of the century, due to overfishing. Three species of sturgeon occur in Florida waters. The Atlantic (Acipenser oxyrinchus) and shortnose (A. brevirostrum) sturgeons inhabit the east coast. The Gulf of Mexico sturgeon (A. o. de sotoi), a subspecies of Atlantic sturgeon, is found in the west coast. The Suwannee River supports the largest known sturgeon population in Florida with an estimated 3,000 individuals above 3 kg in body weight and 87 cm in total length. Approximately 300 sturgeon are known in the Apalachicola River, and catch of only a few sturgeon have been reported in other riverine and coastal waters during the last 30 years. Harvesting of sturgeon in Florida is prohibited and, the shortnose and Gulf of Mexico sturgeons are federally protected under the endangered species act. The Atlantic sturgeon is still commercially fished in other eastern seaboard States. Necessary actions for species recovery have been delineated in recovery and management plans, in draft form for the shortnose sturgeon and official form for the Gulf of Mexico sturgeon. These plans emphasize determining the size and

geographically distinct management units of existing populations and, identification and restoration of essential habitat for each species. Coordinated activities between federal and state agencies are stressed to increase the effectiveness in enforcement of rules and regulations to reduce or eliminate unauthorized take. Research activities to identify, assess and eliminate known and potential threats to the species are also featured. Sturgeon population viability is linked to the size of the breeding stock, which are extremely sensitive to overfishing because of delayed sexual maturation (8-30 years) and long reproductive cycles (2-5 years). For this reason, and for aquaculture purposes, artificial propagation techniques for sturgeon have been developed by universities and privately, during the last few years. Contemporary restoration efforts for sturgeon species are ultimately dependent on environmental protection and population augmentation efforts. Most important, successful implementation of activities for recovery will require public awareness. A limited, artificial stock enhancement program for sturgeon is an option worthy of consideration for recovery of the species in Florida.

The Evolution of Political Efforts to Restore Lake Apopka

James Conner, David Stites, and Michael Coveney. (St. Johns River Water Management District P. O. Box 1429, Palatka, FL 32178-1429)

Lake Apopka, once the crown jewel of Central Florida's waterbodies is now considered the most polluted large lake in the state. An understanding of the political, economic, and social forces that brought about Lake Apopka's demise and the evolution of efforts to restore the lake can be a valuable study for water managers facing similar environmental problems. Lake Apopka is a prime example of changes in the valuation of the State's water resources. In Florida water was once treated as a resource to be exploited with an infinite capacity to absorb human activity. Agricultural development of the former littoral zone and floodplain sawgrass marshes of Lake Apopka during World War II led to the degradation of the lake in the late 1940s. The condition of the surface waters in the state was still not a broad public issue when in the early 1960s Lake Apopka was recognized as a damaged system in need of restoration. Between that time and the advent of the Lake Apopka Restoration Act of 1985, a public discussion ensued that stimulated a procession of newspaper articles, several decades of studies (conducted by a variety of government agencies and academic institutions), and unsuccessful attempts to restore the lake. Activities associated with the lake came to be viewed by the public as disjointed, uncoordinated and ineffectual. Cynicism, frustration, and a general concern for the future of the lake mounted along with the effects of the continuing pollution from the lakeside farms. Continuing economic losses that resulted from the collapse of recreational uses and the downstream pollution caused by the flow of Lake Apopka water to the Harris Chain of Lakes became increasingly apparent and created additional publicity. These mounting issues and public concerns were finally translated into the Lake Apopka Restoration Act of 1985, which established the Lake Apopka Restoration Council and authorized the SJRWMD to begin the coordinated

restoration of the lake. That act was folded into the more comprehensive SWIM (Surface Water Improvement and Management) Act of 1987, under which the District restoration efforts continued. These legislative efforts, the ensuing activities, and heightened public interest spawned The Friends of Lake Apopka, which has provided the visible and vocal voice of the community. The concurrent efforts of the District, the Friends of Lake Apopka, and a now well informed public have engendered additional support for restoring the lake. The voices of all the shareholders in the lake's future are now being heard, and comprise an essential component of the restoration.

P Loading Limit for Lake Apopka - The Essential First Step

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External phosphorus loading to Lake Apopka has increased historically to more than 0.6 g P m^{-2} yr^{-1}, primarily through development of agriculture on former littoral and floodplain sawgrass marshes. The lake has retained most of this extreme phosphorus load, and the flocculent sediments deposited since about 1950 contain some 1350 metric tons of P and average 32 cm in thickness. The magnitude of reduction in P loading necessary for restoration of Lake Apopka and the future role of internal loading from the sediment P pool were key issues in developing the restoration program. Through comparison with a reference set of lakes and interpretation of the Florida narrative standard for P, a target range of 0.038 to 0.055 mg P l^{-1} was set for Lake Apopka. An input-output model was used to predict the maximal annual loading of P from all sources (approx. 0.13 g P m^{-2} yr^{-1}) that is compatible with the target concentration range. Lake Apopka clearly can be restored, although internal recycling of P from the sediments might delay recovery of the lake after P loading is reduced. Evidence indicates that heavy internal P loading, if it occurs, will be transitional. Existing mechanisms for P transformation in the lake water and sediments will continue to sequester P in forms that are poorly biologically available. Case studies of a variety of lake systems, including shallow lakes, support the conclusion that Lake Apopka will respond to decreased external loading. The restoration plan includes further steps (the marsh flow-way filter, mass harvest of gizzard shad, littoral planting) that will minimize the transitional effect of internal P loading from the sediments and accelerate the re-establishment of vegetated habitat.

Response of a small Orlando lake to hydrated lime additions

Forrest E. Dierberg[1], Thomas A. DeBusk[1] and Kevin McCann[2] ([1]DB Environmental Laboratories, Inc., Rockledge, FL, [2]Stormwater Utility Bureau, City of Orlando, Orlando, FL)

Hydrated lime [Ca(OH) 2] was applied to Lake Beauty, a 0.97 ha (mean depth 1.5 m) lake in downtown Orlando. The dosage was calculated in the laboratory according to four criteria: the exchange acidity of the sediments; the base neutralizing capacity in the water column; the control of pH during liming such that pH 10.0 is not exceeded; and the longevity of the adjusted pH. The final concentration applied in the field was 77 mg Ca(OH) 2 per liter of lakewater. Water column Secchi disk transparency (SD), chlorophyll a (Chl a), and total P concentrations improved within 24 hours after lime application. Calcium and alkalinity concentrations in the lake decreased to values less than background levels, indicating the lime caused a $CaCO_3$ floc in excess of the added calcium and alkalinity, resulting in a softening of the lakewater. SD transparency and Chl a concentration returned to pre-liming levels after only 9 days, and total P concentration returned to the pre liming value after one month. However, the pH continued to remain more than 1.0 unit higher than background for one month post liming. The short-term response of the lake to lime addition is discussed with respect to previous liming studies in non-Florida lakes, with a prognosis of the long-term outlook.

An estimate of nutrient loads from properties with septic tanks to Allen's creek

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The Allen's Creek Watershed is a typical urban stream located in the central portion of Pinellas County. As part of an ongoing effort to develop a watershed management plan for the Allen's Creek basin, information was gathered on the number of properties with septic tank systems within the watershed. A formula developed by Ayres and Associates, Inc. was used to estimate nutrient load to the creek using information specific to the Allen's Creek Watershed as well as literature values for nutrient concentrations. Pinellas County records indicate approximately 18,109 properties in the Allen's Creek watershed of which 1,674 were identified as properties with septic tank systems. A comparison of estimated nutrient loads from properties with septic tank systems and runoff indicates that septic tank systems, even under best case scenario contribute more nutrients to the creek than stormwater. If the worst case is true for the Allen's Creek watershed, properties with septic tank systems contribute approximately 4.4 times as much nutrient load as stormwater. It is important to point out that all of these calculations are based purely on estimates and are not supported by field data. The results of this mathematical study suggest

the need for further investigation of the nutrient loads contributed by properties with septic tank systems and runoff. A monitoring program is recommended that will collect data in the Allen's Creek watershed to confirm the relative importance of both sources of nutrient loading. A SWMM model is also being developed that will give another estimate of runoff load.

Fish and Fishing on Orange Lake

James R. Estes (Florida Game and Fresh Water Fish Commission, 7922 NW 71st Street, Gainesville, FL 32653)

Historical trends in the sportfish populations and sport fisheries of Orange Lake were evaluated. Orange Lake sportfish populations and fisheries experienced dramatic fluctuations since 1977. Declines in largemouth bass and black crappie abundance have been noted since 1989. Persistent low water levels in the early 1990's coincided with declines in all sportfish populations. Harvestable-sized bluegill and redear sunfish populations appeared to respond more quickly than the catchable-sized largemouth bass populations to rising lake levels. Multivariate models were developed to test hypotheses concerning the effects of droughts and hydrilla coverage on harvestable-sized bluegill, harvestable-sized redear sunfish, harvestable-sized warmouth, available forage, young-of-the-year largemouth bass and catchable-sized largemouth bass. According to the models developed, harvestable-sized bluegill, harvestable-sized redear sunfish, harvestable-sized warmouth, young-of-the-year largemouth bass abundance and biomass of available prey were positively influenced ($P < 0.1$) by hydrilla and negatively influenced by duration's of droughts. The mechanisms by which hydrilla and drought affected fish populations were believed to be related to quantity and quality of fish habitat. The utility of the models to aid in management decisions was discussed. Water level "management" could have optimized fish population response to fluctuating water levels during the most recent drought. A common sense approach to resource management was urged when using mathematical modeling to aid in decision making.

Squeaky Wheel Workshop: How To Get Action on Your Lake Issue

Sandy Fisher[1] and Curtis Watkins[2] (1 Florida LAKEWATCH, Department of Fisheries and Aquatic Sciences, University of Florida, Gainesville, Florida. 2 City of Tallahassee, Stormwater Management Department, Tallahassee, Florida.)

Once a problem on a lake has been recognized and solutions considered, the next step is to take action. This process frequently involves getting the cooperation of a diverse group including lake users, regulatory agencies, and government. Where do you start and what approaches may be useful?

1. Lake users describe what approaches have worked (and what haven't) to achieve lake management goals.

2. Professionals describe ways to interact effectively with regulatory agencies and government.

Everyone is encouraged to contribute her/his perspective and to ask questions during the workshop.

Health Management and Disease Investigation in Florida's Largemouth Bass Populations

Ruth Francis-Floyd (DVM, MS, Department of Large Animal Clinical Sciences and Department of Fisheries and Aquatic Sciences, University of Florida, 7922 NW 71 Street, Gainesville, FL 32653)

Since 1988 a number of cooperative studies have been carried out by Florida Game and Freshwater Fish Commission biologists and University of Florida (College of Veterinary Medicine and Department of Fisheries and Aquatic Sciences) scientists which were intended to further understanding of disease outbreaks of free-ranging largemouth bass and develop techniques to monitor health status in populations of concern. A comparative hematology study was carried out between 1989 and 1991 which included largemouth bass populations from three central Florida lakes, Weir, Holly and Newnans. Analysis of data has provided baseline values for development of seasonal and annual means of important red blood cell parameters. Limited data were also collected on white blood cells and total plasma protein concentrations. This information is being used to assess disease in living fish with the goal of developing non-lethal techniques for monitoring health status of wild populations. Investigation of poor condition factors in largemouth bass from Lake Harris resulted in isolation of a Mycoplasma-like organism from several Centrarchid species. Organisms in this group are well-recognized as a cause of chronic disease, debilitation, and reproductive failure in domestic mammals. A study was carried out in which fingerling largemouth bass were exposed to the organism through intraperitoneal injection and monitored carefully for growth and condition factor over a 16 month period. The organism was demonstrated to be non-pathogenic and subsequent laboratory studies indicated that it was in the genus Acholeplasma, which is closely related to Mycoplasma, but usually non-pathogenic. Several investigations of fish kills while they were in-progress have improved understanding of naturally occurring diseases in largemouth bass. Two epizootics of Edwardsiella tarda, a bacterial disease, have been documented. One occurred in Orange lake in 1991, and another in 1995 in waters connecting to the Appalachicola River. A complaint of tumors in fish from Lake Hollingsworth was determined to be parasitic in origin, rather than being related to pollution or human activity.

Sources of Organic Carbon in the Food Webs of Three Florida Lakes Indicated by Stable Isotopes.

Binhe Gu, Mark V. Hoyer and Claire L. Schelske. (Department of Fisheries and aquatic Sciences, University of Florida, 7922 NW 71st Street, Gainesville, FL 32653)

Stable carbon isotope ratios of biota were employed to track the sources of organic carbon flows of three Florida lakes that differed considerably in trophic state (indicated by chlorophyll a level). Phytoplankton dominated the diet of consumers in Lake Apopka, a hypereutrophic, phytoplankton-based system. Consumers in Lake Deaton may be isotopically divided into three clusters and were supported by phytoplankton, terrestrial carbon and a combination of these sources, respectively. In contrast, consumers in Lake Okahumpka, a macrophyte-dominated, clear-water system, showed heavy dependence on epiphytic algal carbon. Isotope evidence indicated that the most abundant primary producer, Vallisneria americana, was not exploited to any great extent in this lake. Stable isotope analysis appears to be a powerful tool for elucidating carbon pathways in lake food webs.

Evaluation of water management alternatives for Orange and Lochloosa lakes: effects on lake levels and wetlands.

G. B. (Sonny) Hall, C. Price Robison and Chris Ware, St. Johns River Water Management District, Palatka, Florida

Hydraulic changes (e.g., weirs, levees, canals) within Orange Creek Basin (OCB) have altered the natural hydrology of Newnans Lake, Orange Lake, Lochloosa Lake, and Paynes Prairie and have been suspected causes of ecological degradation. Concerns have increased regarding both the ecology and the economics of OCB. In response to these issues, the St. Johns River Water Management District initiated a study to evaluate the ecological effects of different surface water management alternatives on OCB. This paper documents the development of the hydrologic computer models, biohydrologic criteria and methods used to evaluate these water management alternatives, and the findings of our investigation for Orange and Lochloosa lakes. Twenty-two water management alternatives were evaluated for Orange and Lochloosa lakes. The water level fluctuation regimes predicted by the hydrologic computer model for each alternative were evaluated for potential ecological impacts to the lakes. These ecological evaluations compared the predicted hydrologic regimes to key environmental attributes of the lakes. These comparisons provided a scientific framework to determine which water management alternatives were likely to maintain the hydroperiods needed by the biological communities.

Using Remote Sensing and GIS to Support Melaleuca Management Efforts in Lake Okeechobee

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The exotic, woody tree melaleuca (*Melaleuca quinquenervia*) was first introduced into Lake Okeechobee during the 1940s. Since that time, melaleuca has spread at varying densities into approximately 20 percent of the lake's 40,000 ha littoral zone. This has resulted in the loss of valuable wildlife habitat and threatened the ecological integrity of the lake ecosystem. Because of the detrimental environmental impacts caused by the continued spread of melaleuca, the South Florida Water Management District has initiated an aggressive melaleuca management plan to reduce the areal coverage of melaleuca in Lake Okeechobee. During the past two years, more than 20 million melaleuca trees have been killed using aerial and labor intensive manual herbicide applications, and additional work will be conducted this year. In order to support management efforts by monitoring short and long-term changes in the lake's melaleuca population, a baseline GIS database documenting the location, condition, density, and areal coverage of melaleuca was developed. Vegetation information was interpreted from 10 m panchromatic SPOT satellite imagery and color infra-red photography, then converted into a digital ArcInfo database. The baseline database will serve as a benchmark against which future melaleuca coverages can be compared and, the efficacy of the District's melaleuca management efforts can be evaluated. Additionally, a GIS database documenting the location and areal coverage of all aquatic vegetation in Lake Okeechobee is being developed. This database will be used to monitor successional changes in plant communities following management activities and/or changes in the physical and chemical environment.

Effects of groundwater seepage on nutrient loadings and bacteriological inputs to clear lake

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Clear Lake is a 148-hectare urban lake located in Orlando, Florida. Development within the Clear Lake watershed began to accelerate substantially in the 1960s, accompanied by a steady decline in water quality within the lake. Approximately 22 % of the 576-hectare watershed for Clear Lake uses septic tanks for waste disposal, while the remaining area is equipped with a sanitary sewer collection system. Elevated levels of coliform bacteria are often observed in Clear Lake, with fecal coliform bacteria frequently exceeding the criterion for recreational waters. Seventeen seepage meters were installed in shallow and deep areas of Clear Lake during January 1994 with samples collected in large polyethylene bags on approximately a biweekly basis for evaluation of seepage quantity and quality.

Seepage flow was found to be substantially greater near sub-basin areas utilizing septic tank systems than near sub-basin areas with sanitary sewer collection systems. On an annual basis, seepage flow was found to contribute approximately 22% of the estimated annual hydraulic inputs to Clear Lake. In general, elevated levels of total nitrogen were found in groundwater seepage entering Clear Lake, with mean seepage concentrations of total nitrogen ranging from 2000-7000 µg/L. The area of highest total nitrogen concentrations in groundwater seepage was found adjacent to sub-basin areas utilizing septic tank systems. Nitrogen inputs through groundwater seepage were comprised primarily of ammonia and NOx with seepage concentrations of these parameters approximately 20-300 times greater than values measured in the water column. Elevated levels of total phosphorus were also found in groundwater seepage inputs into Clear Lake, with values ranging from approximately 20- > 300 µg/l, with highest concentrations adjacent to septic tank areas. In addition, coliform bacteria populations were found to be substantially greater near subbasin areas utilizing septic tank systems. On an annual basis, groundwater seepage was found to be the primary nitrogen source entering Clear Lake, contributing approximately 39% of the annual nitrogen loading and 15% of the annual inputs of total phosphorus. Contributions of nutrients into Clear Lake through groundwater seepage limit the water quality improvements which can be achieved by treatment of stormwater and dry weather baseflow inputs.

Classification and Assessment of Florida Lakes Using Benthic Macroinvertebrates

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The Florida Department of Environmental Protection initiated lake bioassessment in 1993. An initial regional lake classification based on physiography, natural water chemistry, lake origin, and lake hydrology identified 41 lake classes (Griffith et al., 1995.) Sixty-two reference lakes in 29 classes were sampled in the summers and winters of 1993 and 1994. Lake classes were examined for their ability to account for differences among benthic macroinvertebrate assemblages. Lake classes with similar biota could be combined. The revised classification consists of multiple lake regions with lakes of similar origin, hydrology, and natural water chemistry. Florida lake benthos are more diverse in winter, when hypoxia is less frequent. Distribution of individual taxa within lakes was patchy, but several community measures such as percent composition of families and functional feeding groups were less patchy than individual taxa. Therefore, samples consisting of composite grabs from several sites in a lake are more cost-effective than single grabs. Biological measures were identified that best respond to anthropogenic disturbance or pollution

by comparing benthic data from twenty-nine degraded test lakes to the reference lakes.

The Role of Models in the Water Quality Research Program of Lake Okeechobee

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Lake Okeechobee water quality models synthesize in-lake research results from the past decade. Current model outputs are consistent with several hypotheses concerning in-lake nutrient and algal processes, including light limitation from resuspended sediments, and nitrogen limitation. Additional research needs also are identified by the models. The first need is for better data on readily suspended flocculent sediments. To obtain a reasonable model calibration, it currently is necessary to assume sediment characteristics intermediate between those measured in the consolidated sediments and the water column. This suggests the occurrence of a flocculent "fluid mud" layer overlying the consolidated sediments. This flocculent layer is observed in Lake Okeechobee, but has not been characterized in terms of particle size or nutrient concentrations. Such characterization could improve the accuracy of model predictions. The second research need is identified from flux rates predicted by the model. The model indicates that organic mineralization rates are major factors in the nutrient dynamics of Lake Okeechobee. These rates, not yet measured, now are considered a high priority in the research program. These research needs will improve our understanding of water quality processes and reduce the uncertainty of predicting future trends in nutrient and algal dynamics of Lake Okeechobee.

Swim, freshwater and the Southwest Florida Water Management District

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The SWIM Department of the Southwest Florida Water Management District has developed and begun implementation of SWIM Plans for ten waterbodies within the District. This presentation will center on case studies and projects implemented on SWIM freshwater waterbodies. The discussion will include the format followed in development of SWIM plans and the strategy used for setting Pollutant Load Reduction Goals (PLRGs) on individual waterbodies. An overview of some of the more interesting data, observations, conclusions and conjectures drawn from SWIM funded studies and projects will be briefly presented (e.g., groundwater nitrate loading, paleolimnology, modeling approaches, habitat/wildlife relationships, zooplankton dynamics, whole lake alum application, habitat restoration).

Historical Trends in Aquatic Vegetation at Orange Lake, Florida

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Orange Lake, a 9000 acre lake in Alachua County in north peninsular Florida supports a regionally significant recreational fishery and provides habitat for a wide range of aquatic and wetland species. These resources may be affected by the proliferation of floating vegetation mats and islands, which reduce open water habitat and prohibit or restrict recreational opportunities. In this study photointerpretation and geographical information system (GIS) techniques were used to document changes in aquatic vegetation and area of open water over a fifty-eight year period from 1937 to 1995. The extent of open water habitat fluctuated from a high of 7748 acres in 1975 to a low of 5054 in 1991. About two thirds of this change appears to be attributable to the growth of aquatic vegetation. The remaining changes in extent of open water are probably due to lake stage fluctuation. Between 1937 and 1995 free floating vegetation increased from 1779 acres to 2540 acres. Deep marsh, primarily yellow water lily, *Nuphar luteum,* increased dramatically from 152 to 1024 acres. *Nuphar is* generally considered to have high habitat value for fish and other aquatic organisms. The effects of increases in free floating vegetation are more difficult to assess.

Documentation and evaluation of a lake level and aquifer protection plan (ALTERNATE PAPER)

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Lake Alice, located at the University of Florida (UF.), has received various amounts of treated and untreated wastewater for almost three-quarters of a century. In addition, the lake is a depository for stormwater and effluent from UF heating and cooling equipment. Because these hydraulic inputs exceeded the systems storage and output capacities, injection wells were drilled through the lake bottom that allowed excess water to drain into the Floridan aquifer. Injection water was found to contain high levels of coliform bacteria, and a lake level management plan was devised to cease pollution of the aquifer. Before the plan was implemented, water budget information was available to decision makers that questioned whether lake level would fall and the plan would succeed. However, decision makers put their faith in predictions from a complicated hydrology model and seemingly ignored simple water budgets. Over $11 million dollars were spent on plan implementation, but aquifer pollution continues.

Stakeholder Involvement in Watershed Issues: An Integrated Approach to Surface Water Management in the Orange Creek Basin.

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The Orange Creek Basin (north central Florida) has historically been known for its exceptional ecological significance and the outstanding value of its lake's sport fisheries. Environmental conditions in some areas of the basin, however, have declined with time, particularly over the last few decades. Today, major issues of concern for lakes in the basin (e.g., Orange, Lochloosa, Newnans) include excessive accumulation of organic sediments, deterioration of water quality, loss of native aquatic vegetation, changes in floating and emergent marsh vegetation, proliferation of hydrilla, and recent declines in sport fisheries. In late 1993 the Orange Creek Basin (OCB) Advisory Council was founded to assist the St. Johns River Water Management District (SJRWMD) in the development of a comprehensive, basin-wide surface water management plan for the basin. The overall objective of the basin management plan is to provide a road map of the steps needed to make and implement protection, restoration and management decisions in the basin. Development and implementation of the plan relies on an ecosystem management approach that (a) promotes cooperation, input, and involvement of agencies, stakeholders, and the public, (b) integrates environmental, economic, and community goals, and (c) provides for a continuous auditing of progress toward goal achievement. The OCB plan identifies priority issues concerning basin-wide surface water management and restoration needs, establishes issue-specific goals, develops strategies to attain those goals, and describes the programs and projects necessary to implement those strategies for goal attainment. Fish and wildlife populations, recreational opportunities (including sportfishing), and economic benefits from recreation are all considered important components in developing subbasin ecosystem goals. Other agencies, the OCB Advisory Council (and/or other "basin stakeholder" councils), and the public will continue to provide input to the plan as it is implemented.

The status of the Lake Apopka Restoration Program

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More than ten years of research have led to the development of a restoration program for Lake Apopka. Implementation of this program requires a substantial reduction in P discharges from lakeside farms. To accomplish this reduction, initiatives are underway to obtain regulatory authority, to secure funding, and to examine the feasibility of alternative means for load reduction. Regulatory authority could be achieved through specific legislation, through appeal of a previous judicial

ruling, or through the setting of standards by the Environmental Regulatory Commission. Funding is being sought through state legislation and through discussions with Federal agencies. Several alternatives for decreasing the discharge are being examined. The probability of success is highest for alternatives involving substantial or complete acquisition of farmland by the state. Land acquisition offers the most certain, most complete, and most natural solution for discharge reduction. Other alternatives under consideration include 1) disposal of discharges in infiltration basins and through overland flow and 2) treatment of discharges with alum in a settling basin. These latter alternatives would allow a greater acreage of farmland to remain in operation but would require substantial and continuing expenditures for operation and maintenance.

Northwest Florida Water Management District lake and river planning and management programs

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The Northwest Florida Water Management District is currently engaged in a number of planning and resource management efforts for lake and river systems throughout its sixteen-county jurisdiction. These efforts are focused primarily upon preservation of current water quality and ecosystem health; however, the District is also involved in some waterbody and wetland restoration efforts. Because financial resources are severely limited due to a constitutional cap on the ad valorem taxing ability of the District (one twentieth of that available to the other four water management districts), funding from programs such as SWIM, state and federal grants, Preservation 2000, and local governments is used for virtually all surface water projects. Recent and current projects include: extensive research and interstate coordination to develop a basin wide water management mechanism for the Apalachicola-Chattahoochee Flint River system; lake restoration (sediment removal) and installation of stormwater retrofit systems for Lake Jackson in Leon County; watershed and water quality/biological data collection for Deer Point Lake reservoir in Bay County; Diagnostic/Feasibility assessment for restoration of Lake Munson in Leon County; restoration of Tates Hell Swamp in Franklin County and extensive land acquisitions throughout the northwest Florida. Upcoming projects include development of SWIM plans for the St. Marks/Wakulla River system and the Choctawhatchee River and Bay system.

Surface Water Improvement and Management Program Initiatives in the Suwannee River Water Management District

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The two major goals of Florida's Surface Water Improvement and Management (SWIM) Program are the preservation of water bodies in good condition and the restoration of degraded aquatic systems. Because of the nature of land use in the Suwannee River W.M.D. (forestry, agriculture and minimal urban development), most water bodies in the District are in relatively good condition, and the primary thrust of the District's SWIM Program has been preservation. Five of the six SWIM priority waters on the SRWMD Priority List are river systems with an overall goal of preservation. Only one SWIM waterbody, Alligator Lake, has a restoration emphasis. The District's approach to preservation consists of basically four key components:1) Monitoring of water quality, aquatic biology and land use to evaluate the condition of the resource on an ongoing basis and applied research to generate the data needed to incorporate sound science into the decision-making process 2) Interagency coordination to maximize the effectiveness of existing regulatory, monitoring and planning programs and to utilize the expertise of other agencies to conduct research and monitoring. 3) Local government technical assistance to support good land use decisions by the government entities most responsible for land use and development - local governments. 4) Public information and outreach to enlist the support of the public and develop "grass roots" partnerships.

Ecological issues and status pertinent to water transfers from the Suwannee River drainage

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The Suwannee River drainage (25,770 km^2) is the second largest river system in Florida. Mean daily flow is 298.5 m^3/sec. The Suwannee has been identified as one of only 42 major river drainages in the continental U.S. still largely free-flowing and unaffected by major withdrawal or diversion projects. The river exhibits five distinct reaches, plus its estuary. Biotic communities in each region have specific water needs and hydrologic requirements. The estuary is river-dominated, suggesting that reductions in freshwater inflow would alter its salinity and ecological characteristics. Better quantifying linkages between groundwater input and stream flow and developing interstate basin management are important needs for protection of the river/estuary ecosystem. In 1977, the Army Corps of Engineers published a water resource study for western peninsular Florida which included an evaluation of the transfer of water from the Suwannee drainage to west central Florida. To date this represents the most detailed proposal to move water from northern to southern Florida. Periodic water shortages during times of drought in the Tampa Bay area often result in a renewed interest in water importation from some segments of the public and local politicians. Public demand to address hydrologic impacts on lakes and wetlands in northern Hillsborough and Pasco counties and resulting limitations on wellfield withdrawals in the Northern Tampa Bay Water Use Caution Area have also increased demands to find alternative/additional supplies of water. The challenge for the agencies responsible for making water allocation decisions

(primarily the Southwest Florida and Suwannee River Water Management Districts) will be to blend sound science with the socio-political dimensions of this issue.

Polynuclear Aromatic Hydrocarbons: Sediment and Plant Interactions

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The plants and sediments of two shallow, sub-tropical lakes in north Florida (Lakes Jackson and Hall located in Leon County) were sampled, identified, and analyzed for PAH content. Stations were chosen so that areas affected by stormwater and relatively pristine areas were surveyed. Sediments from areas that received stormwater runoff were found to have elevated Polynuclear Aromatic Hydrocarbon (PAH) concentrations, while stations distant from stormwater input were characterized by lower PAH concentrations. The PAH content of rooted vegetation was found to have a significant relationship with the concentrations of PAHs in the sediments upon which they grew. There was no relationship between the PAH concentrations in non-rooted plants and the sediments where they were found. Plant growth and PAH assimilation experiments were performed on sixty-six plants that included indigenous rosette monocots and vittate dicots which were planted in sediments spiked with varying concentrations of PAHs. These sediments were completely segregated from the water column which was verified by analysis. The sediment PAHs exerted a deleterious effect on the growth of the subject aquatic macropytes, and the PAHs from the sediment entered the plants through their root systems. These experiments showed that the roots of aquatic plants will reach a PAH concentration almost nine times higher than the PAH concentrations of their shoots. There was a difference in the types of PAHs which were accumulated by the plants: the most readily accumulated PAHs were the most water soluble. The evidence indicates that partitioning occurs from the aqueous phase. There were species-specific differences in the degree of accumulation of sediment PAHs. Saturation phenomena for PAH bioconcentration were observed. A model was developed that incorporated equilibrium constants, constants for adsorption and desorption, and saturation levels of PAHs for aquatic plants. The field data, the microcosm experiments and the model all lead to the conclusion that aquatic macrophytes accumulate sediment PAHs acropetally and transport them to their shoots. This study has implications in the distribution and succession of aquatic plant communities and the bioremediation capacity of different types of aquatic plants.

Development of a comprehensive lakes management plan for the City of Lakeland, Florida.

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The City of Lakeland recently completed development of a comprehensive lakes management plan. This plan identifies the resources needed to implement a city wide lakes management program. Components of the program include operation and maintenance activities, additional diagnostic/feasibility studies, inlake restoration projects, and watershed/stormwater enhancement projects. Lakes were prioritized using an objective ranking system. A 20 year program schedule was then developed based on lake rankings. Projected costs for program components were based on city experience including the Lake Hollingsworth Diagnostic Study and sediment removal project, and the Lake Parker Southwest Basin stormwater retrofit project. This plan provides elected officials and city managers with annual financial costs associated with implementing a long term surface water management program. The costs are projected over a 20 year period beginning in 1997. A discussion of potential funding sources and their expected revenues is presented in the plan.

The effects of recreation on the water chemistry and submersed plant community of the Rainbow River, Florida

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A year-long study was conducted in order to 1) establish water chemistry data and submersed aquatic plant species distributions and 2) to determine if recreational activity was altering the water chemistry or damaging the plant community of the Rainbow River, a large spring-fed river near Dunnellon, Florida. Water was sampled at nine stations along the entire length of the river every two months. The following values were measured: pH (7.8-8.2), total alkalinity (55-105 mg/L as $CaCO_3$), total nitrogen (0.71-1.07 mg/L), nitrate (0.69-1.07 mg/L), nitrite (0.001-0.006 mg/L), total phosphorus (0.027-0.060 mg/L), total chlorophyll (0.01-4.0 mg/m^3), dissolved oxygen (5.6-9.7 mg/L), temperature (22.1-23.7°C), and total (0.03-1.57 mg/L), organic (0.05-0.47 mg/L), and inorganic (0.01-1.24 mg/L) suspended solids. Ten species of submersed macrophytes were sampled along 20 fixed transects. Sagittaria kurziana, Hydrilla verticillata, and Vallisneria americana, dominated with 49, 7 and 6 percent mean coverage, respectively. Hydrilla was present throughout the river but exceeded 25 percent coverage in only two transects, both in the headsprings. Concurrent sampling of water, drifting aquatic plants, and recreational users indicated that changes in organic and total suspended solid concentrations were significantly correlated ($r = 0.283$ to 0.494 and 0.350 to 0.489, respectively) to upstream recreational activity (motorboats, canoes, and tubers) while changes in inorganic suspended solid concentrations were not. The biomass of drifting (damaged) plants was significantly correlated ($r = 0.646$ to 0.683) to upstream recreational activity. However, quadrat sampling of plants indicated that areas which received higher amounts of recreational use did not have significantly lower submersed plant coverage or leaf densities. Although recreational activity may be removing a small portion of plant biomass from the river, few areas seemed devoid of submersed vegetation due to recreation. Because the Rainbow River is

deeper and wider (and is thus less effected by shading from tree canopy), it seems to be less susceptible to plant damage by recreation than other Florida spring runs such as Ichetucknee Springs.

Successful control of hydrilla and reestablishment of native species on Lake Okahumpka despite long odds

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Lake Okahumpka is a shallow, five-hundred fifty acre, eutrophic lake located in Sumter County, Florida. The once abundant native plant communities on the lake were replaced by the exotic species, hydrilla in 1980. Since that time, hydrilla has dominated the lake despite herbicide treatments and the stocking of triploid grass carp. Due to the lack of success of the on-going efforts, an interagency aquatic plant management plan was developed and implemented during 1990. A major concern of the involved lake managers was that a significant reduction of hydrilla coverage on Lake Okahumpka created the potential to convert the lake from a macrophytic to a planktonic algae based system. In addition, the lake was a popular duck hunting area. Local duck hunters felt that hydrilla was providing necessary habitat for ducks. By using small applications of fluridone over the last five years, hydrilla has all but been eliminated and the native, submerged plant communities have flourished, maintaining water quality and waterfowl habitat on Lake Okahumpka.

An overview of aquatic plant control in lakes

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Eradication of aquatic plants in lakes is seldom possible or desirable. Costs and technical difficulties usually limit the scope of lake management. The maintenance control involves a reduction of the major nuisance population with large and expensive treatment (usually herbicides), followed by smaller, cheaper, routine treatments to maintain water quality at the desired levels. The objectives of this paper are to identify and evaluate the available techniques for aquatic plant control in lakes, rank them based on their effectiveness, and finally make recommendations on the BMP technique for aquatic plant control. There are several technologies available and already in use. They are classified based on their methods of operation. These techniques include preventive, mechanical sediment cover and shading, and herbicides. The preventive or delaying of the introduction of nuisance aquatic plants to lakes is desirable, however the value of this approach is difficult to quantify. Benefits are usually most appreciated during the initial stage of aquatic plant spread and colonization as more areas become affected, the preventive methods have failed and their continued application becomes inappropriate in most circumstances.

Mechanical management may be achieved by dragging, dredging, bottom tillage, dewatering, burial, or cutting with or without removal of plants. These management methods though high in capital outlay are environmentally friendly, and have advantages of improved speed of operation and operational flexibility. The cost involved can be recovered through economic utilization of the plant materials. The sediment cover approach involves covering the aquatic plants with materials such as sand, gravel, clay, polypropylene, burlap, or aquascreen. These applications have largely been unsuccessful because root systems produce shoots that penetrate the covers. However, the use of these materials addresses only the symptoms of the lake problem and have little potential for negative impact. Herbicides are, at times, an effective management tool for the control of aquatic vascular plants, especially in southern waters where exotic plants have become established. Their application in this case can be the only practical treatment. Their use in some countries is restricted. Some case studies are presented while the advantages and disadvantages of these techniques with respect to environmental impact are also discussed.

St. Johns River Water Management District's Water Resource Management Programs

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The St. Johns River Water Management District has been involved in large-scale basin restoration and management projects starting with the Upper St. Johns River Basin Project started with the ACOE in the late 1970s. As a result of the Lake Apopka Restoration Act of 1985 and the statewide SWIM Program of 1987, the District currently has four other major management and restoration projects underway. More recent initiatives were started at Lake Jessup, in the Lower Ocklawaha River Basin and the Northern Coastal Basins. An overview of the nature and status of these projects will be presented as well as the prospects for the continuation of the District's water resource programs in these and other basins. Recent actions by the Florida Legislature and the continuing political climate has required the District to reexamine its role in system restoration and monitoring.

Water Supply Issues for Lake Okeechobee.

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Lake Okeechobee currently functions as a multipurpose regional reservoir. As part of the Central and Southern Florida Flood Control Project (C&SF) the Herbert Hoover Dike, completed in 1965, altered the lake to serve several purposes. These include: (1) flood control, (2) agricultural water use, (3) urban and industrial water supply, (4) protection of wetland and estuarine systems, and enhancement of fish and wildlife

resources, (5) prevention of saltwater intrusion, (6) navigation, (7) recreation, and (8) water supply for Everglades National Park. Lake Okeechobee stores vast quantities of water during the wet season for later use by agricultural and urban users during the dry season. Because the eight functional objectives of the lake are often competing with each other, it has not been possible to manage Lake Okeechobee to satisfy all demands. Water storage capacity is limited by the height and stability of the Herbert Hoover Dike, which protects local communities from flooding. Flood elevation are by the implementation of the regulatory schedule. The schedule determines the timing and quantity of water released from Lake Okeechobee when the lake stage exceeds a certain level, which varies according to season. A further constraint on the Lake Okeechobee storage capacity is the need to protect littoral zone habitat. Extended high lake stages have been found to be harmful to the littoral zone ecosystem. Major projects currently underway, such as Everglades Restoration, are also expected to have a significant water supply requirement that will in part be met by the waters from Lake Okeechobee. As a result of these competing objectives, Lake Okeechobee management has been a form of crisis response, in which the short-term objectives closest to crisis receive management priority. When water levels are too high, the priority is flood control, and regulatory discharges are made to tidewater, often causing impacts to estuarine biota. When water levels are too low, water supply takes precedence, and water use restrictions are implemented in those basins dependent on Lake Okeechobee for supply. Although low lake levels impact regional water supplies, they are generally beneficial in regenerating littoral zone habitat, enhancing the lakes fishery, and providing feeding habitat for wading birds. Historically, urban and agricultural needs have taken precedence over protection of natural systems during flood or drought conditions. In an effort to re-evaluate this tendency, the lake regulation schedule is being reviewed by the US Army Corps. of Engineers with the objective of developing a more "environmentally friendly" schedule. This review of the lake schedule will provide the information and framework needed to balance the eight purposes of this important resource.

Lake Restoration Efforts in South Florida.

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The South Florida Water Management District (District) covers 18,000 square miles that extends from the city of Orlando to the Florida Keys. Over the last century, human impacts in south Florida have resulted in substantial alterations to the Kissimmee River-Lake Okeechobee-Everglades ecosystems. The major impacts include changes in the hydropatterns of the ecosystems, increased nutrient loads from agricultural activities, and the introduction of exotic plants. Lake restoration efforts at the District have been primarily focused on Lake Okeechobee, one of the largest freshwater lakes in the United States. The lake is an important source of water for agriculture and urban users for the area around the lake, and for aquifer recharge during drought for the major metropolitan areas along the east coast of

Florida. The lake is also an important regional resource for fish and wildlife, and supports a commercial fishery. District management plans and implementation efforts have targeted nutrient loading from the watershed and *Melaleuca* control in the littoral zone of the lake. Phosphorus loading has been reduced by over 60% and millions of exotic trees have been destroyed over the last several years. Current efforts to control nutrients and exotic plants will continue until restoration targets are reached, including: long-term average phosphorus loading less than 400 tons per year; average in-lake total phosphorus concentration below 40 ppb, total nitrogen to phosphorus ratio greater than 30 to 1; reduction in algal bloom frequency and blue-green algae; and control of exotic plants.

The decision making process for Florida's aquatic plant management program

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Florida's aquatic plant management program began nearly one hundred years ago when the U. S. Army Corps of Engineers was authorized by Congress to remove the nonindigenous water hyacinth (*Eichhornia crassipes*) obstructions from the St. Johns River and its tributaries. Today 18 nonindigenous plants, six of which are considered to be invasive, are present in 91% of Florida's 450 public waters. Management of these plants is conducted in 80% of the public waters by 20 federal, state and local governments under the coordination of the Florida Department of Environmental Protection. This discussion reviews the management philosophies and decision making process used to select the methods, frequency, and magnitude of aquatic plant management programs. Programs are shaped by precise sciences such as chemistry and hydrology, and less exacting fields including biology and meteorology, and are blended with the highly variable practices of human behavior and economics. The degree of success is contingent upon funding levels, applying appropriate control methods, timing of control operations, the extent to which nontarget plant and animal populations are impacted, and climate conditions. Funding currently plays the most important role in Florida's aquatic plant management program in public waters. Consequently, the prevention and maintenance of small infestations of nonindigenous plants is stressed. When large populations of plants must be controlled, and when management can be afforded, plans must be executed to provide the highest degree of success. Therefore, management programs are formulated using consensus groups of government agency representatives, researchers, management technicians and other interested and qualified stakeholders.