17th Annual Conference of the Florida Lake Management Society

PROGRAM AND PROCEEDINGS

F L M S

Conference Theme:

Integrating Science and Technology to Enhance Lake Management

June 5-8,2006

Casa Monica Hotel
St. Augustine, Florida

Harvey H. Harper and Sharon H. Darling – Editors

F L M S

MISSION STATEMENT

The mission of the Florida Lake Management Society
is to promote protection, enhancement, conservation,
restoration, and management of Florida's aquatic resources;
provide a form for education and information exchange;
and advocate environmentally sound and economically
feasible lake and aquatic resources management
for the citizens of Florida.

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Requests for additional copies of this program and information about the Society may be sent to the following address:

Florida Lake Management Society
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McGlynn Laboratories, Inc.

John Burns (NE Chapter)

<u>AWARDS</u>

The Florida Lake Management Society presents the following annual awards:

The Marjorie Carr Award is the Society's highest award and is given for lifetime work on behalf of Florida's aquatic resources. This award is named in honor of Marjorie Carr who, among other things, organized citizens and brought to an end the proposed Cross-Florida Barge Canal.

> <u>Past recipients include</u>: Hal Scott (1990), Vince Williams (1991), Cassie and David Gluckman (1993), Johnny Jones (1994), Richard Coleman (1995), Nat Reed (2000), Mike Kasha (2001), Everett Kelly (2002), Joe E. Hill (2003), Jake Stowers (2004), and Henry Dean (2005).

The Edward Deevey, Jr. Award is given to an individual for contributing to our scientific understanding of Florida's waterbodies. Edward Deevey was an internationally recognized limnologist and was affiliated with the State Museum of Florida at the time of his death.

> <u>Past recipients include</u>: William Beck (1990), Jim Hulbert (1991), Howard T. Odum (1993), Tom Crisman (1994), Marty Wanielista (1995), Karl Havens (1999), Claire Schelske (2000), and Betty Rushton (2003) – not awarded in 2004 or 2005.

The Scott Driver Award is given to an "activist" who has promoted the restoration, protection, and/or appreciation of Florida's aquatic resources. Scott was a well known activist on behalf of Lake Okeechobee and was a member of the steering committee that founded FLMS at the time of his death.

> <u>Past recipients include</u>: Helen Spivey (1990), Jim Hawley (1991), Wayne Nelson (1993), Jim Thomas (1994), Tom Reese (1995), Judith Hancock (1999), Carroll Head (2000), Mary Carter (2001), Al Cheatum (2002), Thomas E. Fortson (2003), Beverly Sidenstick (2004), and Joanne Spurlino (2005).

The Richard Coleman Aquatic Resources Award is given to a professional who has worked to restore, protect, and/or advance our understanding of Florida's aquatic resources. This award is named in honor of Richard Coleman who was a founder and first president of FLMA and, prior to his death, worked tirelessly to protect and restore aquatic resources throughout the State of Florida.

> <u>Past recipients include</u>: Eric Livingston (1990), William Wegener (1991), Paul Shaffland (1993), Jeff Spence (1994), Sandy Fisher (1995), Kim Schildt (2000), Jess Van Dyke (2001), Patrick J. Lehman (2002), Lothian Ager (2003), Dr. Marty Kelly (2004), and Dr. Harvey H. Harper, III (2005).

The Marjorie Stoneman Douglas Award is given to individuals in the media who report on aquatic resource issues. This award is named in honor of Marjorie Stoneman Douglas who authored the book, "Everglades River of Grass", founded the Friends of the Everglades, and who has been environmentally active in South Florida.

> <u>Past recipients include</u>: John Morgan (2000), Georgia Davis (2001), Victor Hull (2002), Dave McDaniel (2003), and Bob Hite (2004) – not awarded in 2005.

The Bob Graham Award is given to persons elected to office who demonstrate a commitment to lake and aquatic resource conservation. Bob Graham is remembered for his support of many environmental initiatives, including the purchase for preservation of thousands of acres of Gulf Coast wetlands.

> <u>Past recipients include</u>: Robert B. Rackleff and Debbie Lightsey (2001), Shannon Staub (2002), Cliff Barnes (2003), not awarded in 2004, and Senator Ken Pruitt (2005).

The President's Award is given by the President of the Society to an individual for outstanding support of the work of the Society during the past year.

> <u>Past recipients include:</u> Nancy Page (1999), Julie McCrystal (2000), Erich Marzolf (2001), and Chuck Hanlon (2002), Chuck Hanlon (2003), Jim Griffin (2004), and Erich Marzolf (2005).

EXHIBITORS

AMJ Equipment Corporation

(amjequipment.com)

AMJ Equipment Corporation is a manufacturer's representative supplying leading environmental monitoring equipment, including: YSI, Sontek, Teledyne ISCO, Endress+Hauser, and Controlotron Corporation. With over 25 years of experience in research, monitoring and compliance projects from Key West to the Outerbanks of North Carolina, we have proven our ability to provide leading products for Stormwater Monitoring, Water Quality Monitoring, Meteorological, Flow and Level Measurement, and Remote Data Acquisition Systems with Telemetry Capabilities. Our factory trained systems integrators and applications specialists are readily available to assist with field applications, installations, and personnel training.

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Aquatic Eco-Systems, Inc.

(aquaticeco.com)

Aquatic Eco-Systems, Inc., founded in 1978, is the largest lake aeration system, fountain and related product source worldwide. Our staff of fisheries biologists, lake specialists and technicians provides aeration system sizing, installation, product recommendations and repair/troubleshooting services. Get everything you need from one source: our 500-page print or online catalog. For your convenience we have sizing questionnaires, Tech Talks and a product search engine.

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Aquatic Vegetation Control, Inc.

(avcaquatic.com)

Aquatic Vegetation Control, Inc. (AVC) is a nineteen year old Florida corporation offering vegetation management and general environmental consulting services throughout the southeast. Since its establishment as an exotic/nuisance vegetation management company specializing in the control of invasive wetland and upland species, AVC has broadened its scope of capabilities to include chemical mowing, certified lake management, re-vegetation, restoration services, roadside and utility vegetation management, and general environmental/ecological consulting.

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BCI Engineers & Scientists, Inc.

(bcieng.com)

BCI Engineers & Scientists is a multi-disciplinary environmental and engineering consulting firm that specializes in: Government, Land Development, Water Resources, Mining Services, Geotechnical and Investigative Engineering. With offices throughout Florida and highly qualified professional staff, BCI's focus is developing solutions to complex engineering and environmental challenges for our clients throughout the world. For over 25 years, BCI has maintained a reputation of listening to our clients, understanding their objectives and needs, and communicating frequently to accomplish our assignments professionally, timely and within budget.

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CDS Technologies, Inc.

(cdstech.com)

CDS Technologies, Inc. provides products and services to municipalities, public agencies and industry, based on the unique solids/liquids separation technology known as Continuous Deflective Separation (CDS). The CDS mechanism offers a new approach in separating pollution from stormwater runoff by utilizing a non-blocking, indirect screening process. The CDS technology is an effective non-mechanical method of preventing pollutants such as street litter, trash and debris, vegetation and most sediment and the attached pollutants, including nutrients and heavy metals, from entering receiving water bodies. The stormwater treatment units can be manufactured in fiberglass and both precast and cast-in- place concrete. Treatment flow capacities range from 1.0-300.0cfs. CDS units retain 100% of the captured pollutants, even under high flow conditions. Maintenance operations consist of inspections and the periodic, 3-5 times a year, removal of trapped pollutants.

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Cerexagri-Nisso, LLC

(cerexagri.com)

Cerexagri-Nisso, LLC is a leader in the marketing and manufacturing of Aquatic Herbicides and Algaecides and has been involved in the development and sale of these products for over 40 years. The current product line includes various formulations of Aquathol, Hydrothol and AquaKleen. Committed to the Aquatic Plant Management Industry, Cerexagri supports aquatic research in cooperation with Universities , Federal and State Agencies. This research is dedicated to better Aquatic Plant Management techniques resulting in improved Aquatic Habitat and enhancing future use of Aquatic Resources.

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Dredging & Marine Consultants, LLC

(dmces.com)

Dredging & Marine Consultants, LLC (DMC) is an Engineering firm located in Port Orange, Florida. Serving the governments and citizens of the State of Florida responsibly and professionally is our primary goal. DMC offers environmental and engineering services with qualified and experienced professionals in the following disciplines:

- Dredging Engineering
- Marine & Coastal Engineering
- Environmental Permit Process (Local, State & Federal)
- Dredging & Marine Construction Inspection & Monitoring
- Shoreline Stabilization & Protection
- Waterfront Structures (docks, seawalls, piers)
- Marina Design & Improvements
- Wetland & Ecological Restoration Consulting
- Sediment & Water Quality Testing & Monitoring
- Federal Emergency & Management Administration Coordination

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Environmental Consulting & Technology, Inc.

(ectinc.com)

Environmental Consulting & Technology, Inc. (ECT), is a professional engineering and scientific services firm headquartered in Gainesville, Florida, with more than 210 personnel in 14 offices. ECT personnel have completed hundreds of water-related projects in Florida, which have resulted in a wealth of experience in all phases of engineering, sampling/monitoring, permitting, and planning. This experience has been gained from numerous projects involving studies of lakes, streams, spring and estuarine areas; evaluation of existing surface and stormwater systems and components; collection, analysis, and evaluation of water quality data; modeling and evaluation of urban and rural water resources using various in-house computer models; use of a GIS for mapping and cataloging of data; determination of basin and sub-basin watershed characteristics; development of pollutant loadings; wetland delineation and permitting, and design and development of mitigation systems; fishery studies; determination of water level impacts on ecological systems; identification of BMPs; evaluation of point and nonpoint sources; engineering evaluation and design of stormwater collection and distribution systems; implementation of comprehensive water quality monitoring systems; soil sampling; biological sampling; hydrologic/hydraulic modeling; hydric soil determinations; data management; development of TMDLs; preparation of grant applications and other documents to obtain funding for capital improvements; development of master stormwater plans for governmental agencies; and updating master stormwater plans on a continuing basis. ECT's key personnel have served as expert witnesses on many water resource engineering and permitting projects.

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Environmental Research & Design, Inc.

(erd.org)

Environmental Research & Design, Inc. (ERD) is an environmental engineering firm which specializes exclusively in projects related to lake management, sediment inactivation and chemistry, water quality, and stormwater. Virtually all work efforts performed by ERD involve research projects or studies related to lake restoration, water quality, stormwater management, sediment characterization, and sediment-water column interactions. In addition to engineers, scientists, and design professionals, ERD also maintains a fully equipped research laboratory which is certified by NELAC. ERD owns a wide variety of field monitoring equipment for hydrologic, stormwater, surface water, groundwater, and sediment sampling and analysis. ERD has developed a reputation for a high quality and detailed product completed in a timely manner, and has received awards for technical excellence and innovative stormwater practices.

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Erosion Restoration

(erosionrestoration.com)

Erosion Restoration, LLC is a Florida-based company that specializes in installing the Geo-filter tube. The Geo-filter tube is the most cost-effective solution to erosion control. It is quick to install, permanent, and causes next to no impact on the environment. There are many applications to which the Geo-filter tube can be applied. Shorelines can be stabilized or unsightly concrete can be replaced, beautifying the landscape. The Geo-filter tube is ideal for land reclamation projects or even the creation of wetlands.

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GreenWater Labs

(greenwaterlab.com)

GreenWater Labs is a research laboratory and consulting business specializing in algal identification, water quality monitoring and algal toxin analyses. We are committed to providing our clients with solutions to their surface water quality needs. CyanoLab, a subdivision of GreenWater, is one of the first commercial labs specifically equipped to address harmful algal blooms and their toxins.

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CyanoLab

GreenWater laboratories

Hach Environmental

(hachenvironmental.com)

Hach Environmental designs, manufactures, and services Hydrolab and OTT instruments. Hydrolab multi-parameter water quality instruments incorporate multiple sensors into a single housing and are used for either unattended monitoring or sampling and profiling. Now offering Hach LDO on our Multiprobes. Best accuracy and no membranes or electrolyte!! OTT instruments include surface water and groundwater level monitors, precipitation gauges, and complete hydrological and meteorological stations.

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HydroMentia

(hydromentia.com)

HydroMentia Inc. is a water pollution control company specializing in Managed Aquatic Plant Systems (MAPS) for nutrient pollution control. The HydroMentia Team pioneered the development of Algal Turf Scrubber® (ATS™) and Water Hyacinth Scrubber (WHS™) treatment technologies. These proven water treatment methods optimize biological nutrient removal through engineered system design. HydroMentia staff, with nearly 75 years combined experience, includes several of the nation's leading experts in the development and operation of commercial scale MAPS.

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J.F. Brennan Company, Inc.

(jfbrennan.com)

J.*F. Brennan Company* has provided marine construction services for over 85 years. Over the past 15 years Brennan has focused on lake and waterways management services including integrated dredging and dewatering, erosion and scour protection as well as structural repairs to shorelines and dam structures.

Recently, Brennan completed a muck removal project at Lake Osborne in Palm Beach County where we segregated the sand and fine grain muck and dewatered the materials. After dewatering, the dewatered materials were beneficially reused as organic fill on local golf courses.

At the time of this FLMS Conference, using this same ID&D® Integrated Dredging and Dewatering System, Brennan is performing the same services on the C-51 Canal in Palm Beach County. Of particular interest on this project, Brennan is using the output of a high-tech sub-bottom survey performed by Hibbard Inshore to guide the dredge to remove only the muck material. The sub-bottom survey mapping system is extremely accurate and provides a signature and location of all sub-bottom sediment layers.

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"Marine Professionals"
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Kemiron Company

(kemiron.com -- kemira.com)

Kemiron Company is a leading provider of coagulants, flocculants and odor control products for the drinking water and wastewater industry. The Agricultural and Environmental Services Division works with high density livestock operations, lake remediation, and associated industries to provide services and systems for waste, air, water and soil management controls. Our parent company, Kemira, is based in Finland and we have a worldwide presence. We work with processes and companies to provide the tools which benefit the environment. We provide products and services which will control phosphorous and limit algal growth. Through these processes, we can significantly impact the health of lakes, rivers and streams.

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MACTEC Engineering and Consulting, Inc.

www.mactec.com

MACTEC Engineering and Consulting, Inc. (MACTEC) is a nationwide engineering and environmental consulting firm with specialists in over 50 scientific and engineering disciplines. Our core business is engineering for environmental, water resources, transportation, and construction projects as well as a wide range of environmental services such as risk assessment and toxicology, environmental compliance, remediation, permitting and modeling; water quality modeling and nutrient management, watershed planning and management; wetland , stream and lake restorations; stormwater management; BMPS, design and retrofit; and TMDL determinations. MACTEC is currently ranked in the top 5% of Engineering News Record's Top 500 Design Firms, ranked one of the top Southeast design firms by Southeast Construction, and 3rd among 75 firms in the Annual Design Survey.

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PBS&J

(pbsj.com)

PBS&J is a leader in Florida and throughout the US for lake, stream and ecological restoration and water resources engineering. PBS&J, with a staff of over 1000 scientists, engineers and support staff in offices throughout the state, provides a wide variety of services including water and nutrient budget assessments, water quality monitoring, water quality modeling, sediment transport and removal evaluation and design, GIS watershed analyses, watershed management planning, stormwater master planning, wetland restoration and shoreline stabilization, fisheries management, public education and involvement, NPDES permitting, TMDLs, BMAPs, stormwater retrofit, non-structural stormwater source reduction and development of enhanced stormwater treatment regulations and operation and maintenance practices.

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R.H. Moore & Associates, Inc.

(rhmooreassociates.com)

R. H. Moore & Associates, Inc. has continued to represent the industry's leading manufacturers of erosion control systems and products in Florida since 1982. Products include spray-on emulsions, turbidity reducing polymers, soil additives, hydroseeding additives, paper and wood fiber mulches, biodegradable straw and coconut blankets, permanent soil reinforcement mattings, cellular confinement systems, gabion baskets, stone or flexible concrete mattresses and vinyl sheetpiling. Most applications of products support and promote the growth of vegetation with installations both aesthetically-pleasing and environment-friendly. Well-trained, courteous employees provide regulatory agencies and engineers with updated product knowledge and design assistance while also being able to share nearly 20 years of experience with contractors to assure proper installation of the products that have been chosen for specifications.

Heather Nikole Brown, Project Coordinator
Tradeshows & Promotions Coordinator
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SolarBee Reservoir Circulators

(SolarBee.com)

SolarBee, a division of Pump Systems, Inc. of Dickinson, North Dakota, has become the global leader for providing sustainable water quality in any size lake or reservoir. SolarBee solar-powered circulators have reduced the negative effects of excess nutrients in the water column and sediment, without chemicals or grid power, in more than 100 lakes nationwide. SolarBees eliminate harmful algae blooms, can reduce or eliminate invasive weeds, operate silently and are virtually maintenance-free. With an influence of more than 25 acres per machine, SolarBees are an eco-friendly and cost-effective tool for lake restoration - - providing quality water, naturally.

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Stormwater Management Academy

(stormwater.ucf.edu)

University of Central Florida's Stormwater Management Academy is dedicated to advancing the understanding and practice of stormwater management. The Academy employs diverse research methods, a multi-disciplinary team of research scientists, and dozens of graduate students to investigate complex watershed management problems and develop realistic solutions. The Academy strives to be a leading source for stormwater management research, to provide innovative education and training programs, and to be a substantial partner in the effort to protect Florida's water resources. To learn more about Stormwater Management Academy research and publications, visit our website.

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Suntree Technologies
(suntreetech.com)

Suntree Technologies has developed a complete line of products and services to meet the needs of engineers, contractors, and municipalities. The ability of municipalities to retrofit existing stormwater structures with our products saves taxpayer funds, and brings local watershed management within specification quickly. Innovation in the development of stormwater related products and dedication to our client's needs are hallmarks of Suntree Technologies. Suntree Technologies products and services meet, and even exceed, NPDES permitting and TDML requirements for environmental protection.

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Sweetwater Technology
(teemarkcorp.com)

Sweetwater Technology, a division of TeeMark Corp., offers large-scale alum applications to lakes for the reduction of phosphorus and algae control. We use a specially designed barge that can carry half a tank truck of material and distributes it with computer controlled accuracy. We also build continuous injection systems for streams, ponds and stormwater and we do watersheds applications by helicopter.

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Aeration Technologies, Inc.

(www.aerationtechnologies.net)

Aeration Technologies, Inc. designs, manufactures and installs aeration equipment for water gardens, ponds, lakes and marinas. ATI prides itself in the ability to provide the personalized service our customers deserve and still have the ability to service their needs in a timely fashion. 16+ years of experience & staff biologists allows us to provide you what we know to work. Working with Mother Nature is our goal.

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SNF, Inc.

SNF is the world's leading producer of water soluble polymers. These polymers serve as coagulants and flocculants to industrial and municipal applications. Used to accelerate liquid-solid separation, SNF polymers work quickly and efficiently to thicken and dewater dredge material in any operation or environment. As a supplier of solution, emulsion and powder polymer products, SNF has the most complete product line in the market. SNF is also the only polymer manufacturer that designs and builds polymer mixing and application systems internally. SNF is the complete supplier to any application, providing technical assistance, a broad product line and superior application systems.

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CONFERENCE

PROGRAM

17th ANNUAL CONFERENCE OF THE FLORIDA LAKE MANAGEMENT SOCIETY

Conference Theme: Integrating Science and Technology to Enhance Lake Management

Casa Monica Hotel – St. Augustine, Florida
June 5-8, 2006

FINAL PROGRAM

MONDAY - JUNE 5, 2006

5:00 pm-11:00 pm	Exhibitor Set-Up
8:00 am-5:00 pm	Check-In and Registration
8:00-11:45 am	**Workshop 1: Sorting Through Junk: Effective Presentations, Brochures, and Other Media** (Coordinators: Julia Palaschuk and John McGee - Berryman & Henigar)
8:00-11:45 am	**Workshop 2: Nutrient Management Methods** (Coordinator: Harvey H. Harper – Environmental Research & Design, Inc.)
8:00-11:45 am	**Workshop 3: Aquatic Plant Identification and Monitoring** (Coordinators: Ed Harris and Nathalie Visscher – Florida Department of Environmental Protection)
8:00-11:45 am	**Workshop 4**: **Data Management and Exploratory Analyses with Excel** (Coordinators: Erich Marzolf and Elizabeth Mace – St. Johns River Water Management District)
9:45-10:00 am	MORNING REFRESHMENT BREAK
12:00-1:00 pm	LUNCH (provided with Workshop registration)
1:15-5:00 pm	**Workshop 5: Lake and Pond Restoration – The Adopt-A-Pond Approach** (Coordinators: Jason Mickel and Martin Montalvo – Hillsborough County Public Works, and Kelli Levy – Pinellas County Environmental Management/Water Resources Management Section)
1:15-5:00 pm	**Workshop 6: Lake and Watershed Planning Using GIS** (Coordinators: Jim Griffin – University of South Florida, and Ed Carter – St. Johns River Water Management District)
1:15-5:00 pm	**Workshop 7: Cyanobacteria Identification** (Coordinators: John Burns – PBS&J/Everglades Partners Joint Venture, and Andy Chapman – Green Water Laboratories, Inc.)
1:15-5:00 pm	**Workshop 8**: **Managing a Sediment Removal Project** (Coordinator: Shailesh Patel – Dredging & Marine Consultants, LLC)
3:00-3:15 pm	AFTERNOON REFRESHMENT BREAK

TUESDAY - JUNE 6, 2006

8:00 am-4:00 pm	Check-In and Registration	
8:45-9:00 am	Opening Remarks:	Jim Griffin – FLMS President Gene Medley – NALMS Past-President Harvey Harper – Program Chairman / NALMS SE Director

Session 1: Algal Dynamics and Control
Moderator: John Burns

9:00-9:20 am **Toxic Cyanobacteria: Speculation, Facts, and Questions** – Karl E. Havens

9:20-9:40 am **Cyanobacteria Bloom Control Through Habitat Modification: Reversing Eutrophication without Limiting Nutrient Availability** – Christopher F. Knud-Hansen and Michael Lipparelli

9:40-10:00 am **Phytoplankton Dynamics in a Chain of Subtropical Blackwater Lakes: The Upper St. Johns River, Florida, USA** – M.M. Fisher, S.J. Miller, and A.D. Chapman

10:00-10:20 am **Periphyton in a Native (*Eleocharis cellulosa* – spikerush) and an Exotic (*Panicum repens* – torpedograss) Emergent Habitat** – Andrew J. Rodusky, Bruce Sharfstein, and Charles G. Hanlon

10:20-10:40 am MORNING BREAK *(Exhibit Hall)*

Session 2: Dredging / Sediments
Moderator: Shailesh Patel

10:40-11:00 am **ASD© (Acoustic Sediment Definition) Integrated Systems for the Location, Characterization, Removal, and Dewatering of Lake Sediments** – Jim Hibbard and Glenn Green (Continued in Session 12)

11:00-11:20 am **Water Chemistry of Lake Tohopekaliga After Muck Scraping and In-Lake Disposal by Creating Islands –** Mark V. Hoyer, Martin J. Mann, and Tim Coughlin

11:20-11:40 am **Lake Griffin Canal Dredging: A Project Designed to Mitigate the Navigational Impacts Resulting from Enhanced Water Level Fluctuations –** Ron Hart and John H. Kiefer

11:40-12:00 noon **Potential Effects of Sediment Dredging on Internal Phosphorus Loading in a Shallow, Subtropical Lake** – K.R. Reddy, M.M. Fisher, and J.R. White

12:00-1:15 pm LUNCH *(provided)*

TUESDAY – JUNE 6, 2006 (Continued)

Session 3: Lake Apopka / Lake Okeechobee – Water Quality Issues
Moderator: Mike Perry

1:15-1:35 pm	**Improvements in Water Quality in Lake Apopka and the Harris Chain of Lakes -** Michael F. Coveney, Erich R. Marzolf, Rolland S. Fulton, Walter F. Godwin, Edgar F. Lowe, Lawrence E. Battoe, Roxanne Conrow, and Victoria R. Hoge
1:35-1:55 pm	**Hurricane Impacts on Water Quality of Lake Okeechobee –** R. Thomas James
1:55-2:15 pm	**Why Didn't Wind-Driven Sediment Resuspension Prevent Improvement of Water Quality in Lake Apopka?** – E. Lowe, E. Marzolf, M. Coveney, L. Battoe, R. Conrow, and K. Reddy
2:15-2:35 pm	**Assessment of Microcystin in the Northern Lake Okeechobee Watershed** – Therese L. East and Bruce Sharfstein
2:35-2:55 pm	**Cyanobacterial Trends and Responses to Phosphorus Reduction in the Ocklawaha Chain-of-Lakes, Florida** – Rolland Fulton, Michael Coveney, Walt Godwin, and Brian Sparks
2:55-3:15 pm	AFTERNOON BREAK *(Exhibit Hall)*

Session 4: Innovative Techniques in Lake Management
Moderator: Martin Montalvo

3:15-3:35 pm	**The Use of New Technologies to Optimize and Improve Lake Assessments** – James Griffin and David Glicksberg
3:35-3:55 pm	**How to Maximize the Performance of Your Water Quality Monitoring Equipment** – Russell J. Seguin
3:55-4:15 pm	**The Use of New Technologies to Design, Develop, and Implement a State of Florida Water Atlas** – Ron Chandler, Jim Griffin, Rich Hammond, Kevin Kerrigan, Shawn Landry, and Jason Scolaro
4:15-4:35 pm	**Use of Rugged Notebook Computers in Surface Water Investigations** – A.B. Shortelle, G.F. Miller, and J.L. Dudley
4:35-4:55 pm	**Environmental Change Studies of Water Bodies (Lakes/Tanks) In and Around Tikamgarh District (M.P.) by Using Remote Sensing and GIS Techniques** – Anand Kumar Patel, V.K. Sethi, and Rajesh Saxena
4:55-5:15	**Hillsborough County Adopt-A-Pond Program** – Jason Mickel and Martin Montalvo

TUESDAY – JUNE 6, 2006 (Continued)

5:30-7:30 pm **EXHIBITOR'S SOCIAL / POSTER SESSION** *(Exhibit Hall)*

Posters:

1. **Measuring Field-Based Productivity of Vallisneria americana** – Jennifer Tallerico and Mandy Livingston-Calley

2. **Manipulation of Omnivorous Fish Stocks as a Restoration Component for Ocklawaha Basin Lakes** – W. Godwin, M. Schaus, L. Battoe, M. Coveney, E. Lowe, R. Roth, and B. Sparks

3. **Forecasting Lake Elevations for Lake Okeechobee** – J. John Feldt

4. **Why is Lake Blue So Green? – Invisible Watershed Changes and the Threat to Small Lakes in Florida** – Clell Ford

5. **A Conceptual Ecological Model for the Kissimmee Chain of Lakes** – Brad Jones and Gary Williams

WEDNESDAY - JUNE 7, 2006

8:00 am-3:00 pm	Check-In and Registration
8:00 am	Continental Breakfast

Session 5: Lake Apopka / Lake Okeechobee – Aquatic Plant Issues
Moderator: Rick Baird

8:20-8:40 am	**How Low Can We Go? Revising the Lake Okeechobee Operating Schedule: Lake and Estuarine Trade-offs** – Kim M. O'Dell and Pete J. Milam
8:40-9:00 am	**Lake Okeechobee Submerged Aquatic Vegetation, A Short and Dynamic Recent History** – Bruce Sharfstein and Karen Donnelly
9:00-9:20 am	**Hydrologic Influences on the Spatial and Temporal Dynamics of Emergent Shoreline Plants in Lake Okeechobee –** Chuck Hanlon
9:20-9:40 am	**Recent Development of Submersed Aquatic Vegetation in Lake Apopka** – J. Peterson, R. Conrow, and E. Daneman
9:40-10:00 am	**Using GIS to Map Areas of Potential Submerged Aquatic Vegetation (SAV) Re-Establishment in Lake Okeechobee, FL** – Mark Brady and Bruce Sharfstein
10:00-10:20 am	MORNING BREAK *(Exhibit Hall)*

Session 6: Nutrient Impacts and Control
Moderator: Jim Griffin

10:20-10:40 am	**Floating Wetlands for Nitrogen Control in Water Bodies –** Tom DeBusk, Tom Goffinet, David Haselow, and Rick Baird
10:40-11:00 am	**Effects of Increased Phosphorus Loading on Dissolved Oxygen in a Subtropical Wetland, the Florida Everglades** – Paul V. McCormick and James A. Laing
11:00-11:20 am	**Carbon Dioxide Levels and Emissions from Florida Lakes** – Jenney L. Kellogg, Daniel E. Canfield, Jr., and Mark Hoyer
11:20-11:40 am	**TMDLs and BMAPs as Tools for Project Implementation** – Lance M. Lumbard and Terry Pride
11:40-12:00 noon	**Design of the Taylor Creek Algal Turf Scrubber® (ATS™) for Regional Stormwater Treatment in the Lake Okeechobee Watershed** – Mark Zivojnovich, E. Allen Stewart, and R.R. Villapando
12:00-1:30 pm	BANQUET LUNCH / PROGRAM

WEDNESDAY - JUNE 7, 2006 (Continued)

Session 7: Use of Alum
Moderator: Kelli Levy

1:30-1:50 pm	**Treatment of Phosphorus Enriched Sandy Soils in Agricultural Land Prior to Conversion to a Constructed Treatment Wetland –** Alicia M. Steinmetz and Pam Livingston-Way
1:50-2:10 pm	**Effects of Lake Morphology on the Duration of Alum Applications to Florida Lakes –** Heather R. Hammers
2:10-2:30 pm	**Interaction of Hypolimnetic Alum Treatment and Iron Cycling on Internal Phosphorus Loading in a Kettle Pond –** Jonathan G. Blount and Jonathan S. Davis
2:30-2:50 pm	**Factors Affecting the Effectiveness and Longevity of Alum Applications for Sediment Inactivation -** Harvey H. Harper
2:50-3:10 pm	AFTERNOON BREAK *(Exhibit Hall)*

Session 8: Lake Apopka / Lake Okeechobee – Watershed / Water Quality Issues
Moderator: David Evans

3:10-3:30 pm	**Operation and Performance of the Lake Apopka Marsh Flow-Way** – E. Marzolf, V. Hoge, R. Conrow, L. Battoe, and E. Lowe
3:30-3:50 pm	**An Overview of Current and Planned Phosphorus Reduction Projects in the Lake Okeechobee Watershed** – Donald J. Nuelle
3:50-4:10 pm	**Use of Liquid Alum and Alum Residual to Reduce Phosphorus Loading from Former Agricultural Farmlands** – V. Hoge, W. Godwin, E. Marzolf, R. Naleway, and M. Coveney
4:10-4:30 pm	**Impact of Gizzard Shad Removal on Nutrient Cycles in Lake Apopka, Florida** – Maynard H. Schaus, Walt Godwin, Larry Battoe, Mike Coveney, Ed Lowe, Randy Roth, Corey Selecky, Melissa Vindigni, Careyann Weinberg, and Ashley Zimmerman

Session 9: Critters – Small, Medium, and Large
Moderator: Doug Strom

4:30-4:50 pm	**Relating Ocklawaha Basin Lakes Macroinvertebrate Communities to Water and Sediment Characteristics** – Doug Strom
4:50-5:10 pm	**The Structure of the Zooplankton Community Relative to Trophic Status in Three Central Florida Lakes –** John A. Osborne, Chris Carson, and Gloria Eby
5:10-5:30 pm	**Adult Chironomid Response to Directional Lighting Alterations at a Central Florida Lakefront City** – Joseph M. Faella, Jenna M. Moore, and Jonas Stewart
5:30-5:40 pm	**Bioaccumulation in Fish of Residual Organochlorine Pesticides from Former Agricultural Soils** – R. Conrow, M. Coveney, E. Marzolf, E. Lowe, E. Mace, J. Peterson, and P. Bowen

THURSDAY MORNING - JUNE 8, 2006

8:00 am	Continental Breakfast

Session 10: Macrophytes: Can't Live With Them, Can't Live Without Them
Moderator: Shannon Wetzel

8:30-8:50 am	**The Effects of Shading on Pistillate *Hydrilla Verticillata* (L.F.) Royle Transplants from Lake Okeechobee, Florida, USA** – H.J. Grimshaw and B. Sharfstein
8:50-9:10 am	**Submersed Aquatic Vegetation Monitoring in the Upper Ocklawaha River Basin** – John Stenberg, Walt Godwin, Olivia Jarc, and Bob Cooper
9:10-9:30 am	**The Relative Importance of Submerged Aquatic Vegetation for Nutrient Cycling in the Lower Basin of the St. Johns River** – Dean Dobberfuhl and Michele Lockwood
9:30-9:50 am	**Factors Affecting the Maximum Depth of Colonization by Submersed Macrophytes in Florida Lakes** – Alexis Caffrey, Daniel E. Canfield, Jr., and Mark Hoyer
9:50-10:10 am	MORNING BREAK *(Exhibit Hall)*

Session 11: Potpourri – Good Stuff!!
Moderator: Clell Ford

10:10-10:30 am	**Impacts of Boating Activities and Shoreline Vegetation on Water Quality in the Butler Chain-of-Lakes** – Harvey H. Harper
10:30-10:50 am	**Development of Performance Measures to Evaluate Alternative Structure Operating Criteria in the Kissimmee Basin** – Jeremy McBryan, David H. Anderson, M. Kent Loftin, and Christine Carlson
10:50-11:10 am	**Wind and Water Levels in Kissimmee Basin Lakes During the 2004 Hurricane Season –** David H. Anderson

Session 12: Emerging Technologies
Moderator: Harvey Harper

11:10-11:30 am	**Recent and Coming Advances in Eureka Water Quality Instrumentation** – Russell J. Seguin
11:30-11:50 am	**ID&D® (Integrated Dredging & Dewatering) Integrated Systems for the Location, Characterization, Removal and Dewatering of Lake Sediments** – Glenn Green and Jim Hibbard (Continued from Session 2)
10:30 am-12 noon	EXHIBITOR BREAK-DOWN
12 noon	CONFERENCE ADJOURNED

POSTERS

MEASURING FIELD-BASED PRODUCTIVITY OF *VALLISNERIA AMERICANA*

Jennifer Tallerico and Mandy Livingston-Calley
B.C.I. Engineers and Scientists, Inc.
(working at the St. Johns River Water Management District)
Palatka, Florida

The lower St. Johns River flows from the confluence of the St. Johns and Ocklawaha rivers north 156 km, into the Atlantic Ocean at Mayport, FL. Submerged aquatic vegetation (SAV) has been monitored within the lower St. Johns River basin (LSJRB) since 1995. SAV is critical to the heath and productivity of the St. Johns River and is a good indicator of ecosystem health. *Vallisneria americana* is the dominant species of SAV in the lower basin, comprising over 90% of SAV coverage. To better define resource management targets for SAV in the LSJRB, this study was initiated to measure productivity of *V. americana* within the lower basin. There have been no historical studies of *in situ* productivity for *V. americana* in the St Johns River and the darkly stained water (average 180 PCU) and minimal visibility make standard methods very difficult to use. Therefore, new *in situ* productivity methods were developed and tested to monitor the *V.* americana in the freshwater portion of the river. These methods and their results are described below.

Standard productivity measurements have been defined by Short (1987), where leaves are marked using a syringe needle to mark the leaf through the sheath rather than above it. Growth is calculated by measuring the blade elongation in relation to the leaf weight to length ratio. Because of the dark waters in the St. Johns River, notching leaves of intact plants is not realistic. In an attempt to develop a more useful methodology that can be used in the St. Johns, modifications were applied to Short (1987). The first method was applied in 2004, where exclusion cages (5 x 5 ft) constructed from PVC and chicken wire were randomly placed within grass beds to exclude potential grazers. Six cores (6" diameter) with intact vegetation were extracted from random points within the cage, placed in pots, and taken to the boat for marking. Plants within each pot were marked with syringe needles, felt pens, or punched holes, according to Short and Duarte (2001) then returned to their original holes and, still in their pots, left to grow. Measurements were repeated and productivity was calculated two weeks later.

The second and third methods for measuring SAV productivity were employed in 2005. The second method used fishing line secured through the middle of the blade 12.7 cm above the substrate. Once the fishing line was inserted, a flag was placed in the sediment within 15 cm the plant's location. All plants were caged as described above. After a two-week growth period, the height of the fishing line above the substrate was measured. Anything above 12.7 cm was considered new growth. The final method utilized shears constructed to cut the blades to a specific height (12.7 cm) above the substrate throughout the cage. Length measurements above 12.7 cm represented net growth of the leaf. Grass within two 0.25-meter quadrats from each cage was also clipped at the sediment interface and returned to the laboratory for analysis. The entire sample was placed in a drying oven and weighed to provide the initial biomass at $time_0$. After 2 weeks, two additional samples were brought back to the lab from different quadrats within each cage. The previous procedures applied to provide biomass accumulation from plant growth ($time_1$). Cages were removed and the site was left for 2 weeks to allow the plants to recover. The experiment was then repeated.

Results

During the first year (2004), it became apparent that the transplanting technique was problematic. Isolating the plants within pots in the sediment caused the blades to become limp and many times led to mortality (90%). Each individual marking method had unique problems. For example, hole punching caused damage to the blade integrity and increased susceptibility to breakage. It was also difficult to discern differences between punched holes, grazer damage, or broken blades when measuring accrued length. Pen marking required that the blade be dry for the mark to stick, which caused more damage to the blades. The needle-marking technique through the meristem sometimes missed several blades, causing those blades to appear as new growth.

In the second year (2005) the fishing line methodology proved to be very unreliable, as marked plants were lost during the two-week growth period. Upon returning to the site for measurement, tidal inundation had shifted the flags out of the sediment, making it impossible to find the marked plants. Because of these logistical difficulties, this technique was abandoned.

The third and final methodology employed proved to be the most promising. Plants thrived during the growth period and retrieval of samples was straightforward. When calculating productivity, however, it became apparent that the biomass numbers were extremely variable based on quadrat patchiness. In fact, patchiness variability obscured net growth of the plants, making it difficult to accurately calculate productivity.

Future Studies

SAV productivity monitoring will continue during the 2006-growing season utilizing the shear-methodology, with minor changes to eliminate some variability. More, smaller cages (.75 m^2) will be used per site to increase the level of replication. Initial set-up will include cutting all blades within each cage to 12 cm, with no biomass collection. After a four-week time, 3 quadrats will be collected from within each cage. Each quadrat will be trimmed back to 12 cm, and collected clippings will represent new growth (T_1). Initial biomass (T_0) will be the clippings from the substrate interface. Both sets of samples will be dried and weighed. Collecting initial and final biomass from within the same quadrat will control for bed patchiness. After samples are collected, the entire cage will be moved to another area within the same grassbed and the process repeated throughout the entire growing season.

Special thanks to the following people for their help throughout this project:

Dr. Dean Dobberfuhl, Lori McCloud, David Girardin, Dean Campbell, Robert Burks and the Field crew.

References

Short, F.T., Coles, R.G. (2001). “Global Seagrass Research Method.” New York, NY : *Elsevier*. *8*:155-182

Ibarra-Obando, S.E., Boudouresque, C.F., (1994) “An improvement of the Zieman leaf marking technique for *Zostera marina* growth and production assessment”. *Aquatic Botany*. *47*:293-302

NOTES

MANIPULATION OF OMNIVOROUS FISH STOCKS AS A RESTORATION COMPONENT FOR OCKLAWAHA BASIN LAKES

W. Godwin, L. Battoe, M. Coveney, E. Lowe, R. Roth
St. Johns River Water Management District
Palatka, Florida

M. Schaus
Virginia Wesleyan College,
Norfolk, Virginia

B. Sparks
BCI Engineers and Scientists, Inc.
(working at the St. Johns River Water Management District)
Palatka, Florida

A substantial body of evidence indicates omnivorous fish such as gizzard shad that both feed in bottom sediments and filter zooplankton and other seston may play a significant role in the degradation of shallow, eutrophic lakes. Mechanisms involved may include translocation of nutrients from sediments to the water column, recycling of nutrients within the water column, physical resuspension of bottom sediments and reduction of zooplankton biomass that would otherwise suppress algal blooms. Large-scale removal of gizzard shad has been conducted in lakes of the Ocklawaha River basin to provide for direct export of nutrients and to break potential feedback links associated with shad feeding.

Large-scale removal of gizzard shad by commercial gill nets was initiated in 12,465-ha Lake Apopka in 1993 following a successful experimental biomanipulation of 104-ha Lake Denham, which had degraded environmental conditions similar to Lake Apopka. Between 1993 and 2006 almost 6,000 mt of gizzard shad have been harvested from Lake Apopka. This project resulted in direct removal of over 42 mt of phosphorus and 125 mt of nitrogen from the lake. Also, the shad removal resulted in an estimated reduction of annual internal recycling of about 12 mt of phosphorus and 52 mt of nitrogen. Substantial reductions in external phosphorus loading accompanied the gizzard-shad removal in Lake Apopka.

Significant improvements in Lake Apopka water quality were first observed in 1995 and have continued to the point that current phosphorus concentrations in the lake are less than half the average levels prior to 1995. Chlorophyll a concentrations and Secchi visibility have improved substantially as well which was followed by initial recolonization by desirable submersed aquatic vegetation.

Large-scale gizzard-shad harvesting by commercial gill net was implemented in 4,200-ha Lake Griffin in 2002. The initial harvest removed an estimated 79 percent of the harvestable stock of gizzard shad in the lake based upon a Leslie depletion regression of catches. Over 1,000 mt of shad have been removed from the lake between 2002 and 2006. This action resulted in direct removal of over 7 mt of phosphorus and 21 mt of nitrogen from the lake as well as an estimated reduction in annual internal nutrient recycling of about 5 mt of phosphorus and 23 mt of nitrogen.

Significant reductions in external phosphorus loading to Lake Griffin began in the mid 1990s and were followed by declining nutrient concentrations in the lake. Marked improvements in lake water quality were apparent immediately following the large-scale (567 mt) harvest of shad in 2002. The improved water quality conditions have persisted through 2006 and were accompanied by a substantial increase in desirable submersed aquatic vegetation and a reported increase in gamefish stocks.

For both lakes, the impact of reduced internal nutrient recycling on the lake's nutrient budget cannot yet be calculated. Impacts of shad feeding by translocation of nutrients from the sediment to the water column will be substantially greater than from nutrient recycling within the water column. Ongoing research is exploring how gizzard shad in these lakes recycle nutrients. Results should determine whether interruption of feedback links associated with gizzard shad feeding offers significant potential as a lake restoration component for Florida lakes.

NOTES

FORECASTING LAKE ELEVATIONS FOR LAKE OKEECHOBEE

J. John Feldt
National Weather Service - Southeast River Forecast Center
Peachtree City, Georgia

The National Weather Service's Southeast River Forecast Center (SERFC) is responsible for the issuance of hydrometeorological forecasts for Southern Virginia, North and South Carolina, Georgia, Alabama, Northeast Mississippi, Florida, and Puerto Rico. The SERFC produces over 200 hydrologic forecasts for communities and numerous federal, state, and local reservoir systems. In addition, the SERFC produces daily rainfall forecasts and a variety of products and services to communicate information regarding excessive rainfall and the potential for flooding. In support of the hydrologic services program of the National Weather Service Forecast Offices in Miami and Melbourne, the SERFC implemented lake elevation forecasts for Lake Okeechobee and its tributaries in late 2005. These forecasts and programs are especially important during extreme rainfall events, such as inland-moving tropical systems. The SERFC coordinates crucial information regarding lake inflows and potential elevation changes with a number of federal, state, and regional partners, as well as the NWS Forecast Office in Miami and Melbourne, to help maintain public awareness and safety.

To produce inflow forecasts for a reservoir system, mean aerial precipitation (MAP) is computed over an identified basin and a soil moisture model then determines available runoff. Calculated runoff over a local area is combined with any routed upstream flow to produce an estimate of total inflow. However, Lake Okeechobee posed unique forecast challenges. Initially, the SERFC considered three sources of inflow into Lake Okeechobee. Two of these inflows were computed in a traditional manner: inflows from the Kissimmee River Basin and from Fisheating Creek. The third was rainfall directly on the lake.

The Kissimmee River is a channelized system that is undergoing restoration towards a natural stream. The U.S. Army Corps of Engineers (USACE) provides observed mean daily discharges at various structures in the system. These observations help to adjust the simulated forecast of Kissimmee River stream flow entering the lake. Fisheating Creek is traditionally modeled using the NWS River Forecast System (NWSRFS), and a daily forecast at Palmdale, Florida is available in six-hour intervals out through five days. This forecast is available for Palmdale, Florida.

An interesting aspect of Lake Okeechobee is that a significant contribution of inflow is due to actual rainfall on the lake. The SERFC calculates this contribution through the determination of a MultiSensor Precipitation Estimate (MPE). MPE uses NWS Doppler rainfall estimates adjusted with hourly rainfall gage data. In addition, the effect of future rainfall is considered through the use of a 24-hour quantitative precipitation forecast (in 6-hour intervals) prepared by SERFC Hydrometeorological Analysis and Support (HAS) hydrometeorologists.

Outflows from Lake Okeechobee are calculated as an overall daily average from multiple outlet points. The USACE provides “proposals” or estimates of outflows for 14. Losses due to evaporation from the lake are also included in the modeling. By using the forecast of inflows to the lake (including rainfall) and incorporating observed and proposed outflows, the hydrologic model calculates expected lake elevations for the next five days.

Looking ahead, plans include a refinement of modeling techniques including the use of hydraulic models, enhanced modeling of the upper Kissimmee, and integration of wind impacts on the lake. Future plans also include the incorporation of ensemble stream flow prediction (ESP) modeling for Lake Okeechobee. ESP will allow for the production of longer-lead probabilistic outlooks out through several months or more and include input from climate models.

Reference

SERFC Internet Site: www.srh.noaa.gov/serfc

NOTES

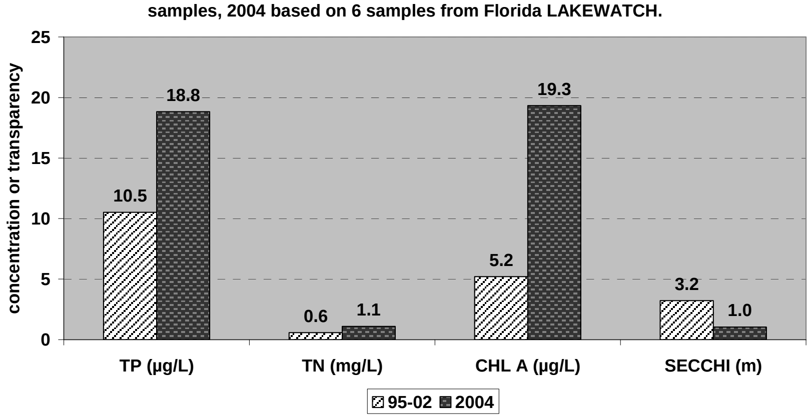
WHY IS LAKE BLUE SO GREEN? INVISIBLE WATERSHED CHANGES AND THE THREAT TO SMALL LAKES IN FLORIDA

<u>*Clell Ford*</u>
Highlands County Natural Resources Department
Sebring, Florida

Lake Blue (13 acres) is located near the town of Lake Placid, Florida. The lake is a closed basin Southern Lake Wales Ridge region lake (depth > 10 m) with a surface water watershed of 150 acres. Relief in this watershed is rather extreme, with a 70 foot elevation change from the top of the watershed to the surface of the lake. The lake watershed soils are entirely Astatula sand. Land use in the lake watershed has been mostly residential for decades, with most residences more than 20 years old. An orange grove is on the northern edge, and US 27 is on the western edge of the watershed. All of the homes in the watershed are on septic tanks, and may also be serviced by grey-water systems for residential laundry. An orange grove, situated to the west in another watershed, was permitted by SWFWMD to withdraw up to 100,000 gallons of water per day from the lake. Direct stormwater runoff to the lake is limited to three small drains. The lake receives most of its water from direct rainfall or through shallow groundwater seepage.

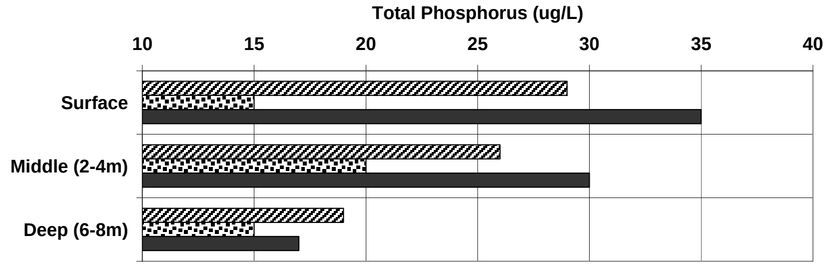
LAKEWATCH water quality data showed the lake to be in good shape with a median of 3.2m Secchi, median TP at 10.5 :g/L, median TN at 555 :g/L and median chlorophyll-a at 4 :g/L from 1995 through 2002. A dramatic change was observed when the grove's surface water withdrawal permit was not renewed and lake water was not being pumped beginning in late 2003 or early 2004. LAKEWATCH data for 2004 are dramatically different, with median Secchi dropping to 1m, TP increasing to 18.8 :g/L, TN increasing to 1030 :g/L and chlorophyll-a levels exploding to 19 :g/L (Figure 1). A consistent LAKEWATCH volunteer has not been identified for Lake Blue since 2004.

Figure 1. Comparison of Lake Blue data. Averages for 95 - 02 based on 121 samples, 2004 based on 6 samples from Florida LAKEWATCH.



Synoptic sampling begun by Highlands County in 2005 showed that for phosphorus, the increase appears to be a surface phenomenon, with median TP values at 29 :g/L which ranged however from 35 :g/L at the surface to 15 :g/L at 6m (Figure 2).

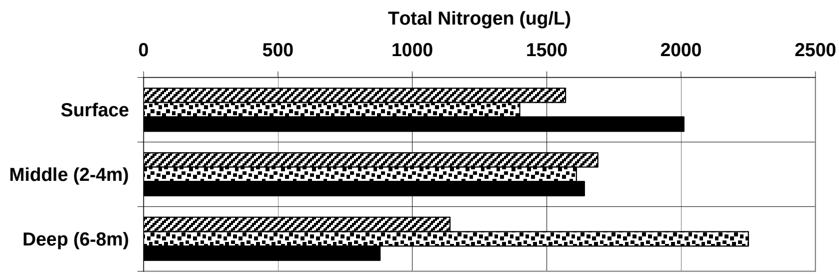
Figure 2. Lake Blue total phosphorus - May05, Aug05 and Apr06 (collected by Highlands County).



	Deep (6-8m)	Middle (2-4m)	Surface
May05 TP (ug/L)	19	26	29
Aug05 TP (ug/L)	15	20	15
Apr 06 TP (ug/L)	17	30	35

The opposite was observed for TN, with median values of 1650 :g/l but peaking at 2250 :g/L at 6m (Figure 3); though not recorded in the spring, significant anoxia in the summer may account for the 1800 :g/L ammonia concentration at 6m.

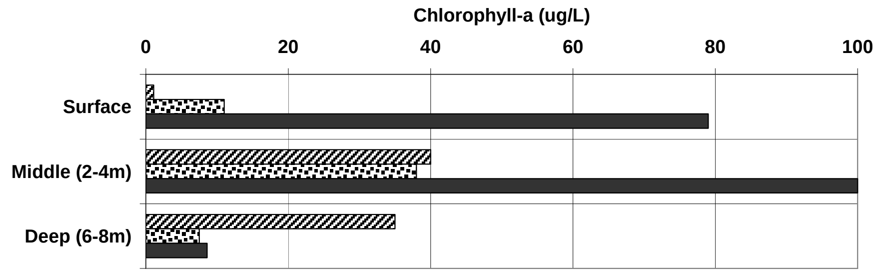
Figure 3. Lake Blue total nitrogen comparison - May05, Aug05 & Apr06 (collected by Highlands County).



	Deep (6-8m)	Middle (2-4m)	Surface
May05 TN (ug/L)	1140	1690	1570
Aug05 TN (ug/L)	2250	1610	1400
Apr06 TN (ug/l)	880	1640	2010

Chlorophyll-a values, which were higher than previously recorded in spring 2005, escalated further in April 2006, topping 100 ug/L (Figure 4). The lake experiences a bloom of algae that approaches noxious levels from February through June. Secchi values now sit at 0.3 m lakewide.

Figure 4. Lake Blue chlorophyll-a - May05, Aug05 and Apr06 (Collected by Highlands County)



	Deep (6-8m)	Middle (2-4m)	Surface
May O5	35	40	1.1
Aug O5	7.5	38	11
Apr O6	8.6	100	79

With the exception of the change in the surface water withdrawal from the lake, there has been no new construction or other change in the lake surface water watershed that could explain changes in lake water chemistry. Residents in the lake watershed are extremely concerned about these dramatic increases in nutrient concentrations.

Though traditional investigations are limited to the surface drainage to a water body, given the sandy nature of the soils in the area and changes to land use outside of the immediate lake surface-water watershed, possible nutrient sources in the less easily defined *groundwater* watershed also need to be investigated. The lake is in dire need of a watershed-wide investigation of water chemistry to determine the source of increased nutrients causing the persistent algae bloom and overall decline in water quality. The County is proposing to determine the water and nutrient budget for the lake, using extensive surface water, groundwater and seepage sampling in the lake and its watershed. Additional actions to be taken in include conducting a survey of fertilizer use, irrigation, septic tank maintenance activities and other activities that might affect lake water quality in the vicinity of the lake. From this information, restoration measures for the lake and its watershed will be proposed, and a lake management plan developed.

NOTES

A CONCEPTUAL ECOLOGICAL MODEL FOR THE KISSIMMEE CHAIN OF LAKES

Brad Jones and Gary Williams
South Florida Water Management District
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A long-term management plan is being developed that seeks to sustain or improve the ecological health of the Kissimmee Chain of Lakes (KCOL), which has been substantially altered by water management and other human-caused disturbances. As part of this multi-agency/stakeholder effort, a conceptual ecological model (CEM) was created that summarizes current understanding of cause-and-effect relationships among anthropogenic drivers of change and ecological components of the KCOL.

The CEM is a simple box-and-arrow diagram organized as a hierarchy of drivers, system stressors, ecological effects, and lake attributes. It illustrates how various cultural drivers and stressors are believed to affect ecosystem components that are of natural and societal value. In the CEM diagram, five drivers, or forcing variables, are linked to five stressors (changes within a lake and adjacent wetlands). These stressors are linked to various ecological effects such as shifts in littoral plant communities and alterations to fish and wildlife habitat. Relationships between stressors and ecological effects represent significant management issues. The ecological effects are connected to five sets of lake attributes that are considered representative of the overall ecological condition of a generalized lake within the KCOL.

The first driver, WATER MANAGEMENT, includes regulation of water levels and flows. Water level regulation is perhaps the system's most influential driver of change. It leads directly to three stressors: altered hydrology of KCOL lakes, decreased instances of lakeshore fires, and drainage of adjacent wetlands. These stressors lead to changes in native plant communities and development of unnaturally dense stands of plants. Additional ecological effects include more tussock formation, accumulation of decomposed plant matter, reduced exposure of sandy substrate, and general alteration of fish and wildlife habitat. Littoral vegetation that becomes excessive may require expensive treatment or removal that can disrupt recreational use of the lake.

The next driver, SHORELINE DEVELOPMENT, leads to two ecosystem stressors: drainage of wetlands and fire suppression. Again, these stressors can result in the ecological effects mentioned above, although in some cases, lakefront development has led to clearing of vegetation or even elimination of the littoral plant community entirely.

The third and fourth drivers are INTRODUCTION OF EXOTIC PLANTS and AQUATIC PLANT MANAGEMENT. Invasive exotic plants produce stress in multiple ways. Numerous exotic plants have become established within the KCOL, with hydrilla being one of the most common and problematic species. Proliferation of exotic species impacts native plant communities and contributes to sediment accumulation and biochemical oxygen demand. Control of these invasive plants has become extremely important to lake management and has itself shaped the habitat of some lakes in the Kissimmee Chain. Consequently, AQUATIC PLANT MANAGEMENT is itself considered as a driver of the ecosystem, although it is unique in that it helps control some sources of stress, thus providing benefits to the system. These benefits include control of overgrowth of native vegetation in addition to exotic plants. However, in the process of reducing proliferation of exotic plants and native vegetation, AQUATIC PLANT MANAGEMENT may introduce complications, including negative impacts on non-target plant species and ecological stresses resulting from hydrologic manipulations to facilitate treatments.

The last driver, INTENSIFIED LAND USE, is thought to cause stress to the KCOL primarily through its effects on various aspects of lake water quality, especially alterations to nutrient levels. Nutrient enrichment leads to multiple ecological effects, including increased prevalence of algal blooms, higher turbidity, decreases in submerged aquatic vegetation, changes in aquatic plant communities, and more internal nutrient loading within lakes.

The lake attributes at the bottom of the CEM diagram are the focus of the next phase of plan development. Five categories of attributes were identified: (1) water quantity, (2) aquatic and wetland vegetation, (3) birds and threatened and endangered species, (4) fish and aquatic fauna, and (5) water quality. Within these five categories, certain attributes were identified that have been or can be affected by anthropogenic changes to the lakes and their watersheds. These candidate attributes (e.g., littoral vegetation, hydrilla, largemouth bass, wading birds, snail kites, trophic state) may be considered as endpoints for lake management. They are being evaluated for development into measures that will be used to track the success of management efforts and to signal needs for changes in management. Specific variables or metrics will be chosen to quantify the selected attributes. These **indicator metrics** will be proposed as important and potentially useful measures of the status of important attributes. A subset of these indicator metrics will be developed into **assessment performance measures** that identify target levels or directional change in these metrics, if sufficient reference data or other reliable information is available. These assessment performance measures, both individually and collectively, will provide benchmarks against which the success of KCOL management efforts can be judged.

NOTES

PRESENTATIONS

SESSION 1

ALGAL DYNAMICS AND CONTROL

TOXIC CYANOBACTERIA:
SPECULATION, FACTS, AND QUESTIONS

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Introduction

Intense blooms of cyanobacteria (blue-green algae) occurred in Florida lakes, rivers and estuaries during summer 2005, probably resulting from ideal weather conditions superimposed on nutrient levels sufficient to support high algal biomass. Agency and university scientists reported high concentrations of the cyanobacterial toxin microcystin in the surface scum of certain blooms. Such 'toxic algal blooms' are common across the USA and in other parts of the world, and when they occur there often is a high level of public concern regarding impacts to human health and aquatic biota. This concern stems from the understanding that microcystin is a hepatotoxin that has causes liver damage in mice when exposed to high concentrations of purified toxins, and various studies where aquatic biota have displayed adverse responses to similar laboratory exposures. The aim of this paper is to provide an overview of the potential ecological impacts of toxic algal blooms, in the context of (1) what actually has been documented; and (2) what we still don't know – i.e., priorities for future research.

Methods

This presentation summarizes key information from recent reviews of the literature regarding ecological impacts of cyanobacteria blooms (Havens 2006), and effects of cyanobacterial toxins (Ibelings and Havens 2006).

Results and Conclusions

Cyanobacterial blooms have myriad effects on aquatic ecosystems, including impacts on other primary producers due to reduced light penetration during peak phytoplankton biomass and impacts on macro-invertebrates, fish and other animals due to reduced dissolved oxygen or elevated ammonia during bloom senescence. There also are reports of effects on fish and other biota due to extreme high pH. Dense concentrations of cyanobacterial filaments and colonies can negatively impact herbivorous zooplankton; reducing grazing rates, growth and reproduction – and this in turn may affect higher trophic levels by reducing energy flow in the pelagic food web.

Effects of toxins have been documented mainly in controlled laboratory studies, typically with single species of test biota exposed to purified toxins. Nearly all studies to date have focused on one cyanobacterial toxin – microcystin, and have been done under relatively ideal laboratory conditions. As a result we know very little about how toxins impact natural populations and communities, which may experience simultaneous or sequential exposure to different toxins, and do so in the presence of other factors that might enhance or reduce the effects.

The main conclusion of this overview is that relative to other documented impacts of blooms, ecological impacts of cyanobacterial toxins are poorly understood. Critical future research includes studies to: (1) quantify effects of a wider range of cyanobacterial toxins; (2) quantify effects of toxins when biota are exposed under more natural conditions, including simultaneous occurrence of other stressors, such as high water temperature and low dissolved oxygen; and (3) quantify effects at the community level, considering both direct toxic effects and indirect food web mediated responses.

Lack of solid information regarding ecological effects of cyanobacterial toxins prevents resource managers from making informed decisions and increases the risk that actions will be taken in response to unsubstantiated anecdotal accounts and sensational information in the press.

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NOTES

CYANOBACTERIA BLOOM CONTROL THROUGH HABITAT MODIFICATION: REVERSING EUTROPHICATION WITHOUT LIMITING NUTRIENT AVAILABILITY

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Eutrophic lakes are typically characterized by summer blooms of cyanobacteria (blue-green algae) that are well adapted to warm, stagnant waters and high soluble nitrogen (N) and phosphorus (P) inputs. Many blue-greens also possess intracellular toxins that make them inedible to zooplankton and fish, and when released into water can negatively affect non-blue-green algae. Subsequent decomposition of blue-green algae blooms causes unsightly and noxious surface scum, and depletes bottom waters of dissolved oxygen.

Traditional attempts to control blue-green blooms have consisted of copper-based algaecide application to poison the entire algal community, or via reduction of nutrient availability by controlling external nutrient input and/or fixing soluble P in lake sediments with chemicals (e.g., alum) or hypolimnetic aeration. Although short-term benefits have been shown in many lakes, neither approach specifically targets the elimination of blue-green algae blooms.

However, it has been known for decades that water circulation through intense aeration can prevent algal blooms in small wastewater lagoons. Since 1998, this same phenomenon has been consistently replicated in over a hundred water bodies, from less than an acre up to ten thousand acres, through the long-distance horizontal and vertical circulation induced by a high flow, solar-powered floating water circulator called the SolarBee. With the prevention of blue-green algae blooms, soluble N and P go into edible algae that are subsequently consumed by zooplankton and fish, thereby reducing organic loading to bottom waters.

This can be accomplished without destratifying the whole lake, without sediment disturbance, and without any land-based energy requirements.

Data presented here from several lakes nationwide document sustainable reversals of eutrophication, including significant reductions in chlorophyll a, total P, and pH, and significant improvements in water clarity, dissolved oxygen distribution in the water column, fish activity and vigor, and overall health of the lake ecosystem - regardless of nutrient or light availability.

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NOTES

PHYTOPLANKTON DYNAMICS IN A CHAIN OF SUBTROPICAL BLACKWATER LAKES: THE UPPER ST. JOHNS RIVER, FLORIDA, USA

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The St. Johns River is the longest river wholly contained within Florida, stretching approximately 520 km from the marshes west of Vero Beach to the mouth near Jacksonville. The Upper St. Johns River Basin (USJRB) is comprised of a mosaic of floodplain marshes, lakes, and river channel. The lakes are shallow and high in color. Phosphorus and nitrogen are also relatively high, averaging approximately 0.1 and 2 mg L^{-1}, respectively. Studies of factors potentially limiting algal biomass in the lakes have been inconclusive with respect to whether nutrients or light limit primary production (Aldridge and Schelske 2000). Several of the water bodies of the USJRB have been identified as impaired by the US Environmental Protection Agency and Florida Department of Environmental Protection. Both agencies have identified nutrients as the principal factor leading to increased cyanobacterial biomass, and Total Maximum Daily Loads (TMDLs) have been proposed to control their frequency.

Spatial and seasonal patterns in phytoplankton biovolume and community composition were examined for the six of the USJRB lakes; Blue Cypress Lake, Lake Hell ‘n Blazes, Sawgrass Lake, Lake Washington, Lake Winder, and Lake Poinsett. Phytoplankton were identified, enumerated and total biovolume was calculated for thirty months of data. Cyanobacterial biovolume was compared to monthly water quality data to determine principal factors regulating their proliferation.

There is a general down-river trend in both increasing phytoplankton biovolume, and dominance of the algal community by cyanobacteria. Average monthly total algal biovolume increases down-river, from 0.7 million cubic micrometers per ml in Blue Cypress Lake to 5.6 million cubic micrometers per ml in Lake Winder. There were striking differences in down-river community composition at the division level. Cyanobacteria increase from approximately 2% of the average biovolume in Blue Cypress Lake, to 50% in lakes Washington, Poinsett, and Winder. The diatom assemblage, as well as water quality data, suggests that the lakes are mesotrophic to eutrophic. The most upstream lake also differs in water quality parameters from the other five lakes. It is higher in color and nitrate, and lower in ammonium, total nitrogen, and ionic character then the downstream lakes. A regression model suggests that the major factors influencing cyanobacteria in these lakes are temperature, TKN, stage, and color, with temperature accounting for 54% of the variability in biovolume.

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NOTES

PERIPHYTON IN A NATIVE (*Eleocharis cellulosa* – spikerush) AND AN EXOTIC (*Panicum repens* – torpedograss) EMERGENT HABITAT

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Panicum repens (torpedograss) beds are assumed to have limited light penetration and low dissolved oxygen (DO) due to their dense growth pattern and are consequently thought to provide poor habitat for periphyton and higher trophic-level organisms. Although there is a clear need to control torpedograss because it can form large, monospecific beds and replace native species, this untested hypothesis has provided additional impetus to the SFWMD's control program. As part of a two year study (March 2004 – 2006), periphyton was collected bimonthly in triplicate torpedograss and *Eleocharis cellulosa* (spikerush) beds, in the marsh of Lake Okeechobee. Periphyton tissue nutrient content and physical and chemical water quality variables, including diurnal DO profiles were measured. Water column depth and nutrients were very similar among both habitats, while light penetration and DO were higher in the spikerush habitat. Epiphytic biomass and nutrient tissue content were significantly higher ($p \leq 0.01$) in the torpedograss habitat. All variables were similar for the episammic fraction in both habitats, except for biomass, which was significantly higher ($p \leq 0.01$) in the spikerush habitat. These data suggest that the epiphytic community in moderate to dense torpedograss habitat in the littoral marsh of Lake Okeechobee might be quantitatively more important as a nutrient sink than it is in the spikerush habitat. It is unclear how differences in epiphytic colonization area, grazing activity and light penetration interact to explain the differences observed between the habitats, but the analysis of fish and macroinvertebrate data components of this study may provide some insight.

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SESSION 2

DREDGING / SEDIMENTS

ASD© (ACOUSTIC SEDIMENT DEFINITION) INTEGRATED SYSTEMS FOR THE LOCATION, CHARACTERIZATION, REMOVAL AND DEWATERING OF LAKE SEDIMENTS
(To be continued in Session 12)

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During the last 15 years, there have been significant advances in the technologies, systems and equipment used to precisely locate, characterize, remove, segregate, dewater and beneficially reuse dredged sediments.

Purpose, Scope & Objectives

To introduce and familiarize the audience with proven technologies, systems and equipment that are being used to locate, characterize, remove, segregate, dewater and beneficially reuse sediments from waterways. This presentation will focus on the implementation of Sub Bottom Profiling Sonar.

Methods or Approach

a. **Location, Characterization and Modeling of Sediments**: Hibbard Inshore has worked with J.F. Brennan Co. to develop accurate systems that identify, locate and model in-situ sediments. This data is translated into Brennan's Hypack®/Dredgepack® dredge guidance systems.

b. **ID&D® Integrated Dredging & Dewatering Systems:** Brennan has a fleet of 7 hydraulic, swinging ladder, cutterhead dredges that are driven by our Hypak®/Dredgepak® systems. These dredges can be integrated with any of Brennan's four (4) separate systems to segregate and dewater the sediments.

c. **Beneficial Reuse of Dredged Materials**: In order to beneficially reuse sediments that are dredged from waterways, the sediments must be sufficiently segregated and dewatered. These sediments are then readily transportable and if necessary recombined in their dewatered state and then transported to their final destination.

Findings and Results

C-51 Canal: Brennan is currently using subbottom profiling and modeling from Hibbard Inshore, to guide our dredges on the C-51 Canal in Palm Beach County. The dredges are pumping muck materials to Brennan's ID&D® dewatering system.

Lake Osborne: Lake Osborne, West Palm Beach, Florida is one of the key case histories for the use of the "ID&D®" – Integrated Dredging and Dewatering System. All of the dredged material was quickly and cost-effectively available for beneficial reuse.

Conclusions and Recommendations

With the wide variations of sediments in the waterways in Florida combined with limited space available for deposition and dewatering of dredged material, users of these technologies will be able to incorporate and apply these technologies to your dredging projects.

When properly applied, hydraulic transport is the most efficient and cost effective method to move and place solids. Beneficial reuse of dredged material as well as limited containment areas can now be addressed using our ID&D® System – Integrated Dredging & Dewatering. Brennan has the methods, experience and equipment to adapt to your size and complexity of the project.

Benefits

- Accurate location, characterization of in-situ sediments
- Detailed sub-bottom modeling for dredge cuts
- Earlier project completion
- Minimal public and environmental disturbance
- Continuous process
- No need for extensive settling basins
- Eliminates long pipelines and boosters
- Processes a variety of materials
- Highly automated
- Low turbidity of return water
- Environmentally sensitive – equipment, systems, process chemicals
- Dewatered material is stackable and immediately available for beneficial use
- Streamlines agency permitting

NOTES

WATER CHEMISTRY OF LAKE TOHOPEKALIGA AFTER MUCK SCRAPING AND IN-LAKE DISPOSAL BY CREATING ISLANDS

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Lake succession, in many Florida lakes, is occurring faster than natural processes would account for, thus impairing lake usage and changing lake ecology. Cultural eutrophication, lake water level stabilization and accelerated growth of invasive native and exotic aquatic macrophytes are three primary factors that can result in accelerated rates of lake succession by operating individually or in combination. Lake Tohopekaliga is experiencing accelerated lake succession as a result of all three of these factors. Therefore, the Florida Fish and Wildlife Conservation Commission (FWC) initiated a project in the summer of 2004 by lowering the water level in Lake Tohopekaliga and removing undesirable aquatic macrophytes and associated organic matter. Due to high costs required to transport this material long distances and lack of nearby disposal sites, some of this material was deposited in-lake, forming 29 islands.

Because of concerns that in-lake disposal of muck may impact the water chemistry of Lake Tohopekaliga a water chemistry monitoring program was initiated. Four islands located closest to the long-term water chemistry monitoring stations set up by the South Florida Water Management District were selected for short-term (3 months of monthly sampling) and long-term (2 years of quarterly sampling) examination of water chemistry impacts near constructed islands. At each of the four islands, 3 water chemistry sampling stations were selected along a transect 25 m, 75 m and 150 m from the water-island interface toward the main lake. Approximately 400 meters to one side of each island transect, 3 additional water chemistry sampling stations were selected along a parallel transect approximately the same distance out into the main lake. These stations were spaced the same distance along a transect and were considered control stations.

In the early 1980s the South Florida Water Management District set up four long-term water chemistry monitoring stations (BO2, BO4, BO6, and BO9) in Lake Tohopekaliga. These four stations were also sampled for short-term (3 months of monthly sampling) and long-term (2 years of quarterly sampling) examination of water chemistry to examine potential whole lake changes that may have occurred after the Lake Tohopekaliga enhancement project.

Using repeated measures analysis of variance shows there is no evidence over the short term (monthly samples for three months) suggesting that in-lake islands are impacting the following water chemistry variables in the waters surrounding the constructed islands: color, total phosphorus, total nitrogen, chlorophyll, Secchi depth, dissolved oxygen, specific conductance, pH, total alkalinity, total suspended solids, and organic suspended solids.

Examining the water chemistry at four long-term stations shows that in the short term some water chemistry variables are outside of the 95% confidence intervals calculated from the five years of data collected immediately prior to the lake enhancement project. However, the large input of rain caused by three hurricanes may be the cause of these deviations. Water chemistry monitoring of the individual island and long-term stations will be continued for the remainder of this project to further examine potential impacts of the Lake Tohopekaliga enhancement project on water chemistry.

NOTES

LAKE GRIFFIN CANAL DREDGING: A PROJECT DESIGNED TO MITIGATE THE NAVIGATIONAL IMPACTS RESULTING FROM ENHANCED WATER LEVEL FLUCTUATIONS

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Lake Griffin is 3,811 hectares, located north of the City of Leesburg in Lake County, Florida. The lake is the third largest waterbody in the 12 lake Harris chain. Water levels within Lake Griffin are controlled primarily by two structures: the Burrell Lock and Dam and the Moss Bluff Lock and Dam.

Lake Griffin has degraded water quality and a dramatic loss of littoral zone habitat. In an effort to restore Lake Griffin, the St. Johns River Water Management District (SJRWMD) proposed increasing lake level fluctuations. However, many residents opposed changes in water level regulations that could result in short term loss of navigation, particularly within the lake's access canals. As a result the SJRWMD approached the Lake County Water Authority as a partner to develop a canal dredging project to mitigate for the loss of navigation within these canals. The LCWA contracted BCI Engineers & Scientists, Inc. to complete the final design and to provide technical expertise in managing the project.

The Lake Griffin Canal Dredging Project requires the hydraulic dredging of an estimated 424,467 cubic meters of sediment within 38 canals. Canal lengths vary from approximately 30 meters to 3.2 kilometers in length and from about 7 meters to over 30 meters in width. Both field surveys of canal cross-sections, sediment coring, and sampling programs were conducted on the canals to estimate the sediment volumes and collect sediment samples. A laboratory-testing program was conducted on the collected sediment samples to determine sediment types and physical and chemical characteristics.

The dredging contractor has chosen to utilize a 10-inch auger-type diesel powered dredge. This equipment pumps the canal sediments to a series of 4 to 8 diesel powered booster pumps. The pumps are positioned on floating spud-anchored barges and convey the sediment in a slurry up to 12 miles via a 12-inch, high density polyethylene floating pipeline. Precautionary measures have been taken to appropriately mark, sign, and light the pipeline along its route from each canal across the lake to the disposal area. An appropriate number of marked submerged boat crossings have been constructed so as to not impede navigation by recreational boaters.

Sediment slurry from the dredging is pumped to a 41 hectare submerged and curtained disposal facility located at the former Eustis Muck Farm within the Emeralda Marsh Conservation Area. At the disposal site, prescribed chemicals and flocculants are applied at target injection rates and locations to assist in settling the sediments within curtained cells. The spoil material is being used to restore the historic marsh elevations and to cap residual farm pesticides bound in the sediments.

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NOTES

POTENTIAL EFFECTS OF SEDIMENT DREDGING ON INTERNAL PHOSPHORUS LOADING IN A SHALLOW, SUBTROPICAL LAKE

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Lake Okeechobee (26° 58' N, 80° 50' W) is the largest lake, by area (1732 km^2), in the southern United States. This shallow subtropical lake may be moving from a naturally eutrophic state to a hyper-eutrophic state due to phosphorus (P) loading from the surrounding watershed (Havens et al. 1996). Increased nutrient loading during the 20th century has resulted in accumulation of phosphorus-rich mud sediments in the central region of the lake. The upper 10 cm of these sediments contain approximately 28,700 metric tons of P, and release soluble P at a rate that is roughly equivalent to all external sources (Moore et al. 1998; Fisher et al. 2005). Therefore, internal nutrient loading from the sediments of this shallow lake has become a major concern in restoration programs and dredging an estimated 200 million cubic meters has been considered.

The objectives of this study were to determine (i) the potential impact of dredging on dissolved reactive P (DRP) flux out of sediments and (ii) the equilibrium P concentration (EPCw) of post-dredge sediments. Intact sediment cores from one location representing P laden mud sediments of the lake were obtained. Four simulated dredging treatments were implemented: control (no dredging-current conditions); top 30 cm, 45 cm, and 55 cm sediment removal. Phosphorus release/retention characteristics of sediments determined at water-column DRP concentrations of 0, 0.016, 0.032, 0.064, and 0.128 mg/L. The water column in each core was replaced at approximately 60 day intervals, for a period of 1.2 years, with fresh lake water spiked with respective P concentrations.

Significant decreases in water column DRP were observed only in sediment cores with 0-30 cm dredging. At ambient water column DRP levels, the P fluxes during the first 32 days were 0.4, 0.1, 0. 4, and 0.2 mg P/m^2/day for the 0, 30, 45, and 55 cm dredging treatments, respectively and accounted for 11-38% of total P released during the 431 day study. At the end of the 1.2 year study, estimated EPCw were on the order of 0.033, 0.008, 0.022, and 0.037 mg P/L for 0, 30, 45, and 55 cm dredging treatments, respectively. Dredging the top 55 cm sediments would result in the removal of approximately 123 g P/m^2, as compared to 80 and 108 g P/m^2 for 30 and 45 cm dredging, respectively. Laboratory experiments suggest that dredging can reduce internal P loading. However, further evaluation is needed to determine the extent to which the controlled laboratory experiments can be used to predict fluxes in the lake under natural conditions; and the long-term sustainability of improving water quality by dredging.

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NOTES

SESSION 3

LAKE APOPKA / LAKE OKEECHOBEE – WATER QUALITY ISSUES

IMPROVEMENTS IN WATER QUALITY IN LAKE APOPKA AND THE HARRIS CHAIN OF LAKES

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The St. Johns River Water Management District has been working since the late 1980s to restore water quality and aquatic habitat in lakes in the Upper Ocklawaha River Basin (Lake Apopka and the Harris Chain of Lakes). Diagnostic studies identified phosphorus (P) as the key algal nutrient in oversupply, and reduction in anthropogenic P loading to the lakes is a primary component of the restoration programs. Much of the excess P loading was from farms developed on peat soils in the original floodplains. P loading is being reduced through acquisition of the farms, reflooding to restore aquatic habitat, and management of the restoration areas to minimize P losses. In addition to reduction in P loading, the District's comprehensive restoration plans include a treatment wetland at L. Apopka to remove nutrients and suspended matter from lake water and the harvest of gizzard shad (*Dorosoma cepedianum* Lesueur) to remove P and reduce internal P recycling. A critical goal of restoration is to increase transparency of the lake water to allow regrowth of submerged rooted macrophytes.

The largest agricultural areas were adjacent to Lakes Apopka and Griffin. Here we expected P loadings to decline as a direct benefit of watershed restoration. At L. Apopka, retention ponds were completed in 1993 that allowed reuse of drainage water for about 30% of the farm area. Some reduction in loading began at that time, although acquisition of most of the farms did not occur until 1996 – 1998. Most farm areas around L. Griffin had been acquired by 1994, and early phases of reflooding were underway. In each lake, gradual reductions in P loading have occurred over the past decade or so. We examined the responses of Lakes Apopka and Griffin to reduced P loading. We compared the direct reduction in TP and the indirect improvements in other trophic variables. Finally, we examined the improvements in water quality in lakes downstream from Lake Apopka (Lakes Beauclair, Dora, and Eustis) and in Lake Harris, which is minimally affected by Lake Apopka outflows.

Our methodology was to contrast recent (2003 – 2005) lake water quality values with mean water quality values for an earlier baseline period. For consistency, we used the same baseline periods (L. Apopka 1987 – 1994, other lakes 1991 – 2000) that were used in TMDL calculations, even though these baseline periods include early portions of the restoration phase.

P loading to Lakes Apopka and Griffin declined compared with baseline values, and lakewater TP concentrations decreased. These changes were not uniform through time, due in great part to variable rainfall causing variable tributary and watershed loadings. TP declined in both lakes without the extended delays that have been attributed in other eutrophic lakes to internal recycling from P-rich sediments. Recent TP values averaged 56% and 42% less than baseline TP for Apopka and Griffin, respectively.

In both L. Apopka and L. Griffin, chlorophyll (Chl), total suspended solids, and Secchi transparency improved in approximate proportion to the reduction in TP concentration. These other trophic variables have improved 46% - 60% in L. Apopka compared to baseline values and 42% - 70% in L. Griffin. In both lakes, volunteer growth of native submersed plant species has increased with improved water quality.

Reductions in TP concentrations have propagated to lakes downstream from Lake Apopka. TP declined 51% in L. Beauclair, 37% in L. Dora, and ~ 0% in L. Eustis. Improvements in other trophic variables in downstream lakes were roughly proportional to reductions in TP, with some exceptions. Two lakes in the Harris Chain have shown significant improvements in Chl and Secchi transparency without a concurrent change in TP concentrations.

Two extreme hydrologic events took place during this monitoring period, and the responses of trophic variables to these events differed considerably between Lakes Apopka and Griffin. First, an extreme drought culminated in very low water levels in 2001 and 2002. L. Apopka lost 75% of its volume, whereas water level in L. Griffin dropped less strongly. TP concentrations more than doubled in L. Apopka. In contrast, TP in L. Griffin was unaffected and continued its downward trend.

Second, three hurricanes passed over central Florida in 2004. Water levels rose in both lakes, and flows through the Upper Ocklawaha system increased greatly. TP increased ~75% in L. Apopka and approximately doubled in L. Griffin. Whereas TP and Chl recovered quickly (~4 mo) to earlier levels in L. Apopka, TP and Chl in L. Griffin remained elevated for extended periods. These different responses of water quality variables to drought, high winds and heavy rainfall likely stemmed from the very different sizes of watersheds for these two lakes and the resulting differences in hydrologic perturbations affecting each lake.

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HURRICANE IMPACTS ON WATER QUALITY OF LAKE OKEECHOBEE

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Introduction

Hurricanes Frances and Jeanne passed directly over Lake Okeechobee in September 2004. The storms resulted in 395,000 hectare-m of water and 792 metric tons of phosphorus to be discharged into the lake, a 3 m seiche, wind waves and currents that resuspended and moved sediments throughout the lake, and water levels that increased over 1.6 m. A comprehensive water quality evaluation of these impacts is presented. The short term effects of Hurricane Wilma, which passed over the Lake in October 2005, also are presented.

Methods

Water quality of Lake Okeechobee is sampled on a monthly basis at 35 locations (see James et al. 1995). Data for the 12 months preceding the 2004 hurricanes (September 2003 to August 2004) and after the hurricanes (October 2004 to September 2005) were compared by region of the lake (offshore, nearshore, and littoral) using a Mixed Analysis of Variance statistical model (Littell et al. 1996, James and Havens 2005). Monthly averaged data through March 2006 were used to evaluate impacts of Hurricane Wilma.

Results

Increased water levels in the lake led to lower ion concentrations. As an example, chloride dropped from an average 62 mg/l and 48 mg/L in the littoral and open water regions, respectively, to 43 and 39 mg/L. The similarity of concentrations after water levels increased is consistent with the findings of James and Havens (2005) who hypothesized that increased mixing between the offshore and nearshore region of the lake at high water levels led to increased homogeneity of nutrients.

Resuspension of sediments due to wind wave stresses led to more than doubling of total phosphorus (TP), soluble reactive phosphorus (SRP), total suspended solids (TSS) and turbidity in all regions of the lake. For example, TP in the littoral, nearshore and offshore regions averaged 0.038, 0.075 and 0.120 mg/L, respectively, before and 0.099, 0.202, and 0.244 mg/L after September 2004. From February 2005 until October 2005, steady declines were observed except for SRP. After hurricane Wilma in October 2005 TP, TSS and turbidity again increased.

Changes were also observed for total nitrogen (TN), ammonia (NH_4) and nitrate+nitrite (NO_X). TN increased in the offshore and nearshore region from 1.24 and 1.35 mg/L to 1.93 and 2.12 mg/L respectively. NO_x increased in all regions after the 2004 storms from less than 0.08 to more than 0.6 mg/L, but declined in the summer of 2005 to less than 0.05, possibly due to denitrification. NO_x increased again to more than 0.5 mg/L after Hurricane Wilma. NH_4 appeared to increase in the littoral region from 0.019 to over 0.041 but the variation was too great to consider this significant. The other regions remained close to 0.012 mg/L. The apparent increase in the littoral region may be attributed to decomposition of plant material.

Secchi Disk depth declined in all regions of the lake, from 0.7, 0.6 and 0.4 m in the littoral, nearshore and offshore regions respectively to 0.5, 0.2 and 0.2 m. This decline is attributed to increased turbidity, TSS and color which increased in the nearshore and offshore region of the lake from an average of 47 and 39 platinum cobalt units (PCUs) respectively to 58 and 51 PCUs after. Secchi Disk depth has remained near 0.5 m in the littoral zone and increased to 0.4 and over 0.2 m, in the nearshore and offshore region by October 2005, but declined again after Hurricane Wilma.

Overall effects of low light, high turbidity and TSS have led to declines in Submerged Aquatic Vegetation (SAV). High available nutrients have led to algal blooms, observed in average chlorophyll *a* values above 40 mg/m^3 from August to October 2005. To improve lake conditions in 2006 efforts have been made to lower lake levels. This should allow for reduction of suspended solids, improved light conditions, regrowth of SAV, and reduction of available nutrients.

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NOTES

WHY DIDN'T WIND-DRIVEN SEDIMENT RESUSPENSION PREVENT IMPROVEMENT OF WATER QUALITY IN LAKE APOPKA?

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Lake Apopka is large (125 km^2) and shallow (mean depth = 1.65 m) with extensive areas of unconsolidated flocculent sediments (UCF) of low mean wet bulk density (1.02 g/m^3). The UCF developed during the last half of the 20th century when the lake was highly turbid (mean Secchi depth ≈ 0.2 m) and hypertrophic (mean concentration chlorophyll a ≈ 100 ug/L). In 1987, the average thickness of the UCF was 32 cm.

In 1993, a restoration program was initiated that will lead to drastic reductions in the external phosphorus loading rate (P_L). Full implementation of the program is still years away, but partial implementation has reduced P_L by more than 30 %. Before initiation of the restoration program, it was known that the UCF contained a large store of P (ca. 1,540 m.t.) that far exceeded the P mass of the water column (ca. 45 m.t.) and P_L (ca. 64 m.t./y). The flocculent nature of the UCF and its large P content indicated to many that reduction of P_L would elicit little, if any, improvement in trophic state or turbidity. Bachmann et al. (1999) inferred that all flocculent sediments would need to be removed for there to be any significant response to P_L reduction.

Two years after low P_L in 1993, however, there was a significant decline in water column concentrations of P, chlorophyll-a, and total suspended solids (TSS) and an increase in Secchi depth. Since that time, additional improvements in water quality have occurred (Coveney et al., 2005). In order to better understand the lake's relatively rapid response to reduced P_L, we examined the factors that might limit sediment P recycling and resuspension and, thereby, prevent strong buffering of trophic state and turbidity by the sediments.

Phosphorus in the UCF is largely in forms that weakly participate in the biogeochemical cycle (Reddy and Graetz, 1991). Approximately, 80 % of sedimentary P is in calcium phosphate minerals (apatite, tricalcium phosphate, whitlockite) and residual organic forms. Excluding these refractory forms, and including P in the water column, yields an estimate of bioavailable P of 363 m.t., of which 42 % is Fe- or Al- bound. Adding the estimated P in fish raises this estimate to 380 m.t. of bioavailable phosphorus, still only a fraction of the total sedimentary P. Thus, the pool of bioavailable P is much smaller that the pool of total P. Moreover, it is rapidly converted to refractory forms. These observations lead us to suggest that the pool of bioavailable P is dependent upon P_L and will decline following reduction of P_L.

By assuming that all TSS is resuspended UCF we estimated an upper limit for resuspension, at least for all but uncommon resuspension events. Over a two-year period TSS was measured every 48 hours. The maximum TSS was 170 mg/L and the maximum 48-hour difference was 80 mg/L. A [TSS] of 170 mg/L equates to resuspension of 2.5 % of the UCF or about 0.8 cm. Thus, most of the UCF is not commonly available for resuspension. Modeling of wind-driven resuspension also indicates that atypically strong winds would be required to resuspend more than a small fraction of the UCF. Because estimates of algal biomass suggest that a substantial fraction of the TSS appears to be non-algal, we postulate that there is a pool of detrital matter, derived from recent algal production, that is more easily resuspended and decomposed than the bulk of sediments in the UCF and that this pool constitutes the majority of the non-algal portion of the TSS. Organic matter in the UCF decomposes at a significant rate (half-life = 2.8 y) under aerobic conditions (20% $O_{2;}$ Reddy and Graetz, 1991). Because Lake Apopka is well oxygenated, this recent algal detritus should decompose at this rate or higher. The size of this pool of easily resuspended, recent detrital matter would reflect a dynamic equilibrium between rates of algal production and suspended sediment decomposition and the size of the pool would vary with the rate of net primary production.

The P required to maintain annual net primary production in Lake Apopka far exceeds either the external P load or the mass of bioavailable P. We suggest this high rate of recycling cannot be maintained in the absence of the high P_L needed to maintain a large pool of bioavailable P in the face of high rates of production of refractory P forms. This is the basis for the relatively rapid response of [P] to reduction of P_L. We further suggest that sediment resuspension cannot maintain turbidity in the absence of algal production rates needed to maintain a pool of recent algal detritus that is more easily resuspended than the bulk of the UCF. These sediments will degrade rapidly in the water column and must be maintained by continued high rates of algal production. Thus, once reduced P_L diminishes the pool of bioavailable P and algal production subsequently falls, the rate of production, and pool, of easily resuspended sediments will decline. By this mechanism, the portion of the TSS attributed to resuspended sediments will decline in concert with the algal biomass. Thus, water transparency will improve as trophic state falls.

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NOTES

ASSESSMENT OF MICROCYSTIN IN THE NORTHERN LAKE OKEECHOBEE WATERSHED

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Although there are no established state or federal standards for cyanobacterial toxins their potential health risks are widely recognized. As a consequence, in May 2004, the South Florida Water Management District began routinely monitoring bloom formation and associated blue-green toxins at 5 shoreline sites in Lake Okeechobee. Results from the first year of the study indicated that while blue-green algal toxins in Lake Okeechobee did occur, along with the algae known to produce them, no seriously elevated microcystin concentrations were evident. Recently, however, many of the water bodies located within the SFWMD have experienced prolific blue-green algal blooms and there have been a number of independent reports of significant levels of microcystin encountered in samples from Lake Okeechobee and the St. Lucie estuary. Because the system is highly interconnected and conditions upstream can impact downstream habitats, monitoring efforts were expanded to encompass the lakes from the Upper Kissimmee Basin south to Lake Okeechobee and from Lake Okeechobee to the east and west coast estuaries. Beginning in August 2005, surface water samples from 41 sites were simultaneously collected on a monthly or biweekly basis to determine microcystin concentrations and other water quality parameters with the intent of determining whether there is spatial or temporal variation in cyanotoxin occurrence, and if their occurrence is correlated with particular environmental conditions. Preliminary results indicate that the highest microcystin concentrations occur in Lake Okeechobee and the Caloosahatchee River estuary while the lowest microcystin concentrations occur in the systems to the north of Lake Okeechobee.

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CYANOBACTERIAL TRENDS AND RESPONSES TO PHOSPHORUS REDUCTION IN THE OCKLAWAHA CHAIN-OF-LAKES, FLORIDA

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Water quality in the Ocklawaha Chain-of-Lakes has been severely degraded by nutrient loading, primarily from large agricultural operations. Water quality in the lakes ranges from mesotrophic to hypereutrophic, and the lakes have experienced prolonged severe cyanobacterial blooms. SJRWMD operates a comprehensive restoration lake and watershed program in the basin to manage water quality and habitat for fish and wildlife, including restoration of wetland habitat in former agricultural areas to reduce external phosphorus loading, operation of a marsh flow-way to remove particulate phosphorus from lake water, harvesting of gizzard shad, and re-establishment of desirable aquatic vegetation.

Comparisons among lakes: The phytoplankton communities of all the lakes are dominated by Cyanobacteria. However, Lake Apopka has substantially lower cyanobacterial biovolumes than other lakes in the chain with comparable phosphorus levels. Lake Apopka also has a different cyanobacterial composition, dominated by the nontoxic genus *Lyngbya*, while the other lakes have been dominated by the potentially toxic genera *Cylindrospermopsis* and *Oscillatoria*. In these respects, the phytoplankton community of Lake Apopka more closely resembles that of Lake Okeechobee than that of the other lakes in the Ocklawaha basin. These differences among lakes do not seem to be related to nutrient concentrations or to the ratio of total nitrogen: total phosphorus. Nor do these differences seem explainable by light availability, as estimated by the ratio of Secchi depth: total depth. One possible factor in which Lake Apopka (and Okeechobee?) differs from the other lakes is a substantially higher concentration of nonalgal suspended solids.

Responses to phosphorus reduction: Following external phosphorus load reduction and shad harvesting, Lake Griffin and Lake Apopka have seen substantial improvements in water quality, including decreases in phosphorus and chlorophyll concentrations, and increases in water transparency. In Lake Griffin, cyanobacterial biovolume has also decreased, and there have been changes in the composition, including a decrease in dominance by *Cylindrospermopsis*. The phytoplankton community has shifted from year-round cyanobacterial dominance to cyanobacterial dominance only during the warm season. Cyanobacterial responses to phosphorus reduction in Lake Apopka are less apparent. At best, there has been a modest recent decline in cyanobacterial biovolume, and little apparent change in cyanobacterial species composition. Recent decreases in nonalgal suspended solids in Lake Apopka raise the possibility that if this decreasing trend continues, the cyanobacterial community could come to more closely resemble that in the other lakes in the Ocklawaha River basin.

Relationships between phosphorus concentration and cyanobacteria in the Ocklawaha Chain-of-Lakes indicate that meeting TMDL phosphorus targets for the lakes will significantly improve water quality and reduce cyanobacterial biovolume, but cyanobacteria will still be a prominent part of the phytoplankton community.

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SESSION 4

INNOVATIVE TECHNIQUES IN LAKE MANAGEMENT

THE USE OF NEW TECHNOLOGIES TO OPTIMIZE AND IMPROVE LAKE ASSESSMENTS

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Purpose and Scope

Hillsborough County (HC) has a unique situation when it comes to the management of lake resources in the county. Although the county abounds in valuable lake resources only one natural lake (Lake Thonotosassa) has public access. The remaining lakes have no public access and are therefore considered "private" lakes. The County developed the Lake Management Program (LaMP) in 1996 to assist its citizens in the management of mainly private lakes. LaMP offers education and assistance with lake and stormwater related issues. Through a partnership with the Southwest Florida Water Management District (SWFMD) and the University of South Florida's Florida Center for Community Research and Design (FCCDR), HC developed the web-based Lake Atlas project. As part of this project, HC and FCCDR established the goal to assess the general health of 150 lakes in the county. These assessments were accomplished between 1998 and 2002. The results of the assessments were posted on the Hillsborough Watershed Atlas website. Figure 1 shows how one lake assessment data element (lake bathymetry) is used for the HC Watershed Atlas. Examples of a lake assessment report can be found on the atlas (http://www.hillsborough.wateratlas.usf.edu) on the Lake Resource Page under ecology.

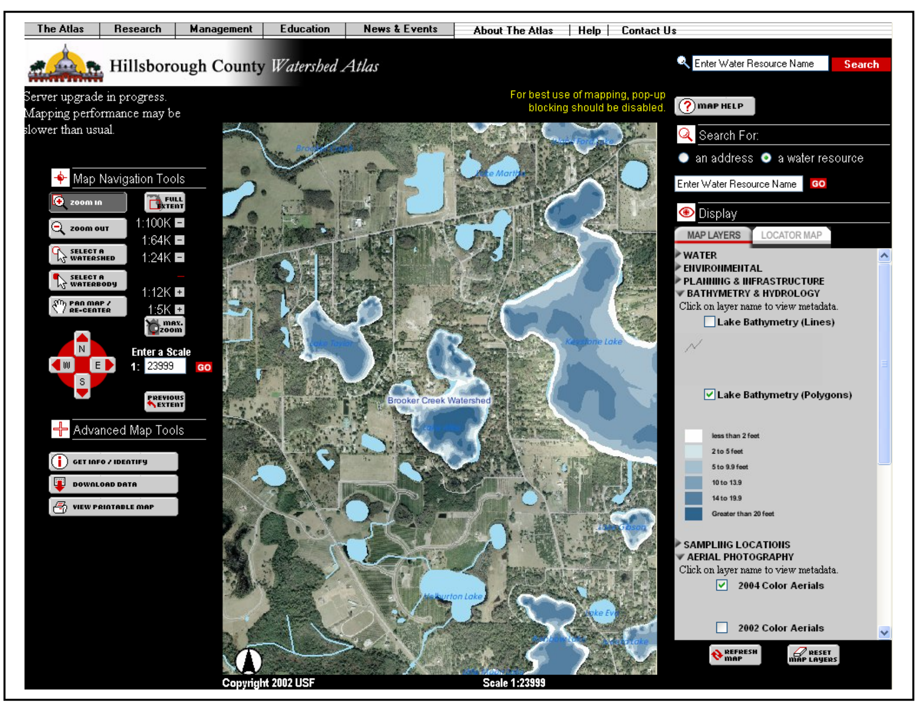

Figure 1.

Hillsborough Watershed Atlas Mapping Component with Bathymetry and 2004 Aerials Selected.

Methods and Approach

The complexity and cost of lake assessments has limited their use in lake management. The research that is planned as part of the next phase of HC lake assessments will explore the application of new technologies to reduce personnel and equipment cost involved in both the data collection and management phases. The approach employs: (1) new “fish finder” bathymetric survey systems that combine positional (x,y,z) accuracy with integrated digital recording and an improved visual display; (2) new portable geographic information systems with check out-check in geographic database technologies and digital camera/GPS technologies; (3) improved water quality sensor technology and a rapid assessment standard operational procedure (SOP).

GIS: We will use GIS mapping and analysis methods to pre-determine the percent area covered (PAC) of emergent and floating plants and extensive pre-field planning to reduce the time required for field investigations and employ mobile GIS to increase the effectiveness of field investigations and reduce the post-processing of field derived data.

Bathymetry: The present bathymetric method used by HC and FCCDR to complete bathymetric maps employs a “Fish finder” for bottom (z data) data and a differential GPS for horizontal (x, y) data. These data are combined in a single time, position and depth record. The resulting record is used to create GIS files which are then converted into a three dimensional bathymetric map. Our research will determine if a new method that employs a fish finder system using an internal WAAS enabled GPS and internal data storage can be substituted for the existing method/equipment. A second advantage of the new method is that the approach also has the potential of creating a record of hard bottom and soft bottom/vegetation returns. We will evaluate this potential capability with the goal of replacing the present method that employs a survey-quality GPS with strip recorder for submerged vegetation assessment.

Water Quality Sensors: New water quality sensor technology which allows the collection of chlorophyll (a) and turbidity in addition to the standard DO, pH, conductivity and temperature will be evaluated to determine how these new data can assist in a rapid assessment of lakes. This effort will be supported by the development of a companion SOP.

Conclusion

The research will lead to a new method for lake assessments which we expect will allow the use of lake assessment protocols as a standard tool in lake management.

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HOW TO MAXIMIZE THE PERFORMANCE OF YOUR WATER QUALITY MONITORING EQUIPMENT

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The use of submersible multiprobes to measure water quality parameters has increased over the last few decades. There are several details regarding their calibration, maintenance, usage that can compromise the quality of data collected. This paper draws upon both theory and testing of various water quality sensors in making some simple recommendations that can improve the quality of field data gathered by typical instruments.

Temperature: Temperature sensors are not usually calibrated by the user; errors are not linear, and cannot easily be corrected. Probes should be verified annually, since they drift with time. The short sensors used in most multiprobes are not completely isolated from the sonde, and can take up to 30 minutes to equilibrate after a step change in temperature. It is important to verify the speed of response of your instrument and adjust your sampling time accordingly.

Specific Conductance (SC): In general, conductivity sensors are very stable, making frequent calibration unnecessary. Electrode fouling, high levels of particulates, gas bubbles, and inaccurate calibration standards, however, can often introduce measurement error. There is no universal temperature compensation that applies to all waters; the measured SC of the sample water may change with temperature, and differ between brands of multiprobes using different temp comp routines. Commercial standards made of NaCl and KCl that read the same at 25 °C can vary by over 10% different at 5 °C! Since SC is defined at 25 °C, calibration near 25 °C avoids this issue. Alternatively, calibrating at sample temperature can lead to improved accuracy if you use KCl standards with an instrument that uses Standard Methods 1.91 %/°C temperature compensation (or by making the appropriate temperature correction for your particular standard).

Dissolved Oxygen (DO): A typical Clark DO electrode signal changes about 3%/°C (pulsed DO about 1%/°C); during air calibration, the air, water, and DO membrane can be at different temperatures, so care must be taken to first achieve thermal equilibration (can take up to 1 hour). Wrinkles or holes in the membrane or internal shorts can cause errors that are not obvious during calibration; a probe should rapidly drop to below 1% DO saturation (<0.1 mg/L) when immersed in a solution of sodium sulfite (zero DO).

To check for inadequate sample circulation, deploy the multiprobe a few feet under the water, and see if bobbing the instrument up and down increases the DO reading. Membrane fouling can also lead to DO errors; while certain technologies such as pulsed and optical probes are less susceptible to passive fouling, a biologically-active film (consuming or producing oxygen) will cause errors in any DO probe. Errors can also be introduced by coated reference electrodes (wash in dilute ammonia) and silver plating onto the gold cathode or exposure to hydrogen sulfide (polish with damp cloth).

<u>pH</u>: Transient pH errors occur after a step change in temperature, due to temperature differences between the pH internal and external reference electrodes (effect cancels out at equilibrium). It is therefore important to be at thermal equilibrium during calibration. Gelled or dirty reference electrodes can cause junction potential errors of over 0.5 pH units, which are not apparent in pH standards; it is recommended to occasionally verify the accuracy of the multiprobe is sample water, using a flowing junction lab electrode. Loss of electrolyte from the reference also causes drift (requiring recalibration), and eventually increases junction potential errors. Finally, all pH probes eventually go bad; it is good practice to replace a probe that exhibits less than a 50 mV per pH unit change during calibration.

<u>Oxidation Reduction Potential (ORP)</u>: ORP is also affected by junction potential errors and loss of the reference electrolyte. In addition, the shift of the reference electrode versus temperature does not cancel out as it does with a pH sensor; a 25 °C shift in temperature causes an apparent 15 mV change in ORP.

<u>Depth</u>: Depth sensors measure pressure, and correct for the density of the water; since the surface water might be at a different temperature and salinity than the deeper water, errors can result. Depth sensors internally correct for temperature effects, and the errors are not linear or constant at all temperatures. The sensor should be re-calibrated at the factory per the manufacturer's recommendation to insure the stated accuracy.

<u>Turbidity</u>: While the use of most turbidity probes provides very reproducible results, there are large differences between commercial turbidity standards and instruments. Even when calibrated in the same standard, two different brands of instruments will read differently in natural waters, due to particle size and shape, wavelength of light used by the instrument, exact path length of the light, the angle of the detector, etc. For best results, a protocol for calibration should be defined and followed, with any changes being documented.

NOTES

THE USE OF NEW TECHNOLOGIES TO DESIGN, DEVELOP, AND IMPLEMENT A STATE OF FLORIDA WATER ATLAS

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Purpose and Scope

A watershed web-based atlas for the entire state of Florida has long been a dream of the University of South Florida's, Florida Center for Community Design and Research (FCCDR) and many of its partners. Until recently, the cost in terms of people, machines and operational budget made this dream impractical. FCCDR now believes that the technologies proven in the *The Tampa Bay Estuary Atlas* (TBEA) (http://www.tampabay.wateratlas.usf.edu/) can be employed to implement a State of Florida Water Atlas (FWA). This paper will present the details of the proposed FWA and the technologies that are now being used to implement the Water Atlas web-site.

Methods and Approach

There are several approaches that FCCDR might take in developing a "Florida Water Atlas" and many are now being explored. One approach is to replicate the design of the *TBEA* in different regions of the state. This would take years to accomplish; however, without significant state or federal funding, this may be the only feasible approach. The second is to gain support from state agencies like the five Water Management Districts and develop five regional water atlases, but with a single design and a single database structure. This approach would possibly take less time than the first, but would never the less take many years to accomplish because of the multiple contracts and probable need to develop five atlas structures before integrating them to a statewide structure. Finally, and most efficiently in terms of time expended, is to reprogram the Water Atlas using the technologies to be discussed in this paper. This effort would require initial state or federal funding to implement, but the long term management costs would be shared by local and regional partner. At present FCCDR is pursuing all options. This paper will concentrate on the regional approach with some discussion of specific additional components being developed that have statewide application.

Regional Approach: The TBEA employs several new technologies that we believe demonstrate the feasibility of a FWA. First is the regional staging area for all spatial and attribute data required to support the atlas. The recent improvements in hydrologic spatial database (National Hydrologic Database) layers with accurate placement of hydrologic spatial data at a 1:24,000 map scale allowed the development of our regional (TBEA) atlas. We now have a staging area design that will support seamless mapping of the Tampa Bay region and our County atlas web sites. Second, we are taking advantage of the new .Net programming effort with the goal to re-write all old applications with .Net. This new technology allows us to significantly improve our current applications including a more efficient and user-friendly exercise of the water atlas database. Finally, FCCDR is upgrading its mapping application to the ESRI ArcIMS 9.1 web service using ArcSDE 9.1 as the storage mechanism for GIS data. This upgrade allows more rapid and efficient serving of aerial maps and images which again improves our ability to meet regional and statewide requirememnts as well as existing local government needs.

***FWA Components*:** In developing its FWA approach, FCCDR has had many detailed discussions with state, regional and county agency representatives to determine the direction our component development will take. A component is essentially a web-based application that is normally designed for specific uses of the underlying water atlas database. A good example of a component that employs new technologies (NHD, .Net and ArcIMS 9.1) is the digital download component. This component, designed in .Net allows the user to access the atlas databases (hydrology, water quality, habitat etc) and apply a number of search criteria (spatial, temporal, waterbody based, governmental boundary based etc) and download data in a user-specified format. The component also allows data retrieval from one, several or all existing atlas databases. Because all our water quality databases retrieve STORET data as one of the many data sources, the scaling of our databases to a FWA database would be reasonably simple. Another example of these new types of water atlas components is the on-line rapid graphing component. This component was designed in .Net using a commercial .Net application, *Dundas Charts*. The new component allows on-line graph creation with specific, selectable bench-marks for hydrologic data and selection of data sources and bench-marks for water quality analysis. A third example currently under development is the online generation of water quality contour map using data from multiple data providers. This new application will be designed with .Net and the ESRI ArcGIS Server in order to provide user-friendly online access to sophisticated mapping techniques, thus allowing users the ability to rapidly map chemical concentration contours from pollution events.

Conclusion

FCCDR is actively pursuing ways to implement a FWA. Recently, we have demonstrated our ability to rapidly support one of the more important state water resource initiatives, the development of basin management action plans (BMAPs) to meet total daily maximum load (TMDL) based requirements. As part of our partnership effort with the Tampa Bay Estuary Program, City of Tampa and Hillsborough County, FCCDR developed a special mapping application and website for the North East Tampa Bay BMAP working group. This website can be updated on a daily basis and contains the latest FDEP impaired water rules (303 d) spatial and attribute data. The application allows the working group to map and display the latest impaired waters by water body ID (WBID) and view the information with selectable background aerials. We are also working with the City of Tampa and Hillsborough County to develop a virtual BMAP component that will document and support the BMAP effort in the Tampa Bay Area. We are also demonstrating through this effort, the statewide importance of such web-components.

NOTES

USE OF RUGGED NOTEBOOK COMPUTERS IN SURFACE WATER INVESTIGATIONS

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Environmental and natural resource studies, including those involving surface water, sediments and aquatic biota are frequently instrument-intensive. Emerging computing technologies, included rugged notebook computers, are now available to collect, display and preliminarily analyze data in the field. Such equipment is specifically engineered to withstand rugged outdoor conditions. These technologies assist in making field teams more efficient and cost effective, and in some cases allow for collection of additional and higher quality data and reduce transcription errors.

"Ruggedized" computers grew out of a demand by the military and police for a lightweight computer capable of withstanding vibration, humidity and dust prevalent in their operational arenas. Early units were permanently mounted in police and military vehicles. This was acceptable for the intended purpose but had limited use for field data collection and analysis. During the same period, PC laptop technologies evolved which allowed business travelers to take their computer with them. "Rugged" versions of the laptop models were developed as a cost effect alternative to fixed on-board computers and are in wide use by police, utility, insurance and other commercial applications.

Today, there are a limited number of manufacturers producing "rugged" laptop computers. Panasonic is the leading producer rugged laptops with numerous models and options available depending on the intended application. The Panasonic "Toughbook" model CF-18 is ideally suited for use in environmental and natural resource studies. The Toughbook has many of the same components as those used in standard laptop computer. However, extra measures to protect the unit from vibration, shock and moisture have been incorporated into the design. For this reason, the Toughbook is priced about 150% more than a standard laptop computer.

The rugged nature of the Toughbook makes it ideal for field conditions where a normal laptop would falter:

- Weather resistant – Sealed port and connector covers, with moisture and dust-resistant LCD, keyboard and touchpad.
- Vibration and drop-shock resistant – Full magnesium alloy case with shock-mounted removable HDD in stainless steel case (rated to withstand a 1.25 m (4 ft) drop onto hard surface).
- Outdoor readable display – TFT active matrix color LCD allows usage in moderate to bright sunlight.
- Usable under extreme temperatures – Rated from 5° C to 35° C (41° F to 95° F) – no fan or external cooling required
- Long battery life - Approximately 6 hours
- Light weight – 2.1 kg (4.5lb)

Rugged computers can be customized to incorporate a number of built-in capabilities to minimize exposure and damage from adverse field conditions:

- Global Positioning System (GPS) Receiver
- Wireless Cellular Data (GSM/GPRS carriers)
- Blue Tooth wireless

Two factors are key to the field application of these computers: configurability - the different options that can be built within a system, and connectivity - the ability to attach various external devices, as needed. Rugged computers may be equipped with interfaces to field sampling equipment and built-in GPS, WiFi and cellular data cards for remote network access. In addition, a key time-saving device, especially when combined with certain software packages, is the touch pad screen of the rugged computer. This allows direct data entry on computer generated forms by stylus or hand written entries.

MACTEC is currently using the Panasonic Toughbooks for a variety of field applications. For example: 316(b) fish and shellfish impingement and entrainment studies, habitat and facilities condition surveys, environmental datalogging, and database uploads. We are also testing their utility in field and laboratory recording keeping in accordance with the Florida Department of Environmental Protection SOPs. A variety of field applications relevant to lake, river, and wetlands projects will be presented.

NOTES

ENVIRONMENTAL CHANGE STUDIES OF WATER BODIES (LAKES / TANKS) IN AND AROUND TIKAMGARH DISTRICT (M.P.) BY USING REMOTE SENSING AND GIS TECHNIQUES

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Tikamgarh District has the largest number of water bodies in the state of Madhya Pradesh including tanks/lakes and wells these tanks are well known as Chandelas tanks which are widely used for tank-bed irrigation, fisheries, drinking purposes and ground water recharging, these tanks, constructed during the 8^{th} and 9^{th} century, by the Chandela kings, constructed about 962 tank, the number of tanks over the years has now been reduced to 421. According to the settlement records, there were 962 tanks constructed during the Chandela period. Over the years the number of water bodies in district has now been reduced due to drastic changes in morphometry of the water bodies, anthropogenic pressure in catchments, encroachments and their environs, most of the water bodies vanished under this pressure, due to heavy siltation, and biotic pressure resulted in reduced water storage capacity of water bodies now they have been going to extinction, land has been going through tremendous transformations due to sprawls in agricultural practices, and urbanization. It was so difficult to provide any scientific solution because no scientific census of these water bodies as well as information is not scientifically compiled. Thus, it is necessary to take a step for sustainable management and restoration of lakes and ponds.

This type of study will provide a scientific conservation and management plan for the district authorities as well as other departments. A lake/tank information system has been developed by GIS, so that various limnological parameters will be assemble /retrieve at any time for the better sustainable management plan.

In the beginning of research work methodology involved field survey, satellite data interpretation and thematic maps generation in GIS environment. The Indian Remote Sensing Satellite data IRS-IC, (LISS-III+PAN) merged latest data have been used and various thematic maps have been prepared.

The study area is located in the northern part of Madhya Pradesh on the Bundelkhand Plateau**.** It extend between Longitudes 78^0 26'and 79^0 21' E and Latitudes 24^0 26' and 25^0 34' N., the district having total geographical area is 5048.00 sq. km, according to census 2001 population of the district is 1,203,160 and population density of 238 persons per km².

The present research deals with lake/tank management plan and information system using remote sensing and GIS techniques and to suggest an innovative water management (renovation) plan for the Tikamgarh district, Madhya Pradesh.

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NOTES

HILLSBOROUGH COUNTY ADOPT-A-POND PROGRAM

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The Hillsborough County Adopt-A-Pond (AAP) Program is an environmental and water resources education program designed to improve the appearance, water quality, and native habitat in historically neglected stormwater ponds. This program, which was established in 1994, works with volunteers who live on or near stormwater ponds to: improve water quality; reduce pollution sources in the neighborhood; increase native plant habitat in and around the pond; reduce litter in the pond; and increase the residents' understanding of stormwater runoff impacts on the pond and on water quality. Our goal is to help a pond group learn how to create and manage a naturally beautiful pond setting.

The AAP staff will guide the group through the stages of pond restoration; from application review and cleanup to planting and through continued management. The AAP Program has a developed policy guideline that allows for a fair and objective review of every pond application. Each pond application must be reviewed to meet a set of criteria such as jurisdiction, wetland and permit restrictions, accessibility, and the presence of a County easement.

If the pond qualifies for the program, and depending on need, we can provide the necessary resources to completely clean out or excavate a pond to give the group a fresh start. Our Specialized Services Unit conducts all operational activities such as excavation, mowing, and minor herbicide applications. After a pond is cleaned out, we provide an education meeting to teach the group about the logistics of the program such as best management practices, wildlife issues, reporting forms, plant identification, and other educational items.

The next phase of the program is to conduct a planting with the pond group. The AAP staff will provide the aquatic plants and provide the expertise to the pond group on planting day. We will provide a design plan to ensure proper plant placement to achieve maximum water quality benefits and survival rate. After planting, the pond group will monitor the plants and continue to maintain the pond and remove invasive plant species on a quarterly basis. All activities by the pond group are reported to the AAP Program. Through our AAP website (www.hillsborough.wateratlas.usf.edu/adopt), pond groups can electronically submit reporting forms including quarterly reports, sampling results, and wildlife checklists.

The AAP Program also offers a variety of programs as part of our youth education and outreach efforts including Officer Snook, Stormwater Ecologist, teach-ins, and guided pond walks. Our adult education programs focus on information that supports best management practices (BMPs) including storm drain marking, reducing fertilizers and pesticides, utilizing native, beneficial plants, creating buffers, conducting pond walks, and providing sampling training. In fact for 2006, the Adopt-A-Pond Program will be emphasizing water quality sampling and reporting through our PondWATCH program. This program will utilize a limnologist to properly train 25-50 volunteers on how to collect and test samples. The goals are to improve and increase our data, add to the volunteer network, and link all data to the AAP website.

Finally, the AAP Program helps meet the requirements outlined in Hillsborough County's National Pollutant Discharge Elimination System (NPDES) municipal separate storm sewer systems (MS4) Permit. Hillsborough County is an operator of an NPDES Phase I MS4 Permit and must develop a stormwater management program (SWMP) that incorporates BMPs, which include measurable goals to implement minimum control measures effectively. Several of these measures are addressed directly through the AAP Program, including public education and outreach regarding the harmful impacts of polluted stormwater runoff, and encouraging public participation and citizen involvement.

NOTES

SESSION 5

LAKE APOPKA / LAKE OKEECHOBEE - AQUATIC PLANT ISSUES

HOW LOW CAN WE GO? REVISING THE LAKE OKEECHOBEE OPERATING SCHEDULE: LAKE AND ESTUARINE TRADE-OFFS

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The current Lake Okeechobee Water Supply and Environmental (WSE) Operating Schedule has a tendency to restrict water releases from the lake, which results in lake stages higher than desirable for the ecosystem. This condition has been exacerbated by recent above average rainfall years and the passage of four hurricanes over the lake or its northern watershed in 2004 and 2005 which resulted in rapid increases in lake stage of more than 4.5'in 2004 and 2.5' in 2005.

This effort will optimize Lake Okeechobee's operating schedule within existing structural constraints to meet the diverse requirements of the Lake, its receiving waters, and its users. This project is being led by the USACE (U.S. Army Corps of Engineers) with Project Delivery Team (PDT) support from the SFWMD as the local sponsor, and input from the U.S. Fish and Wildlife Service (FWS), the Florida Fish and Wildlife Conservation Commission (FFWCC), and the City of Sanibel.

The goal of this reevaluation is to bridge the gap until the Comprehensive Everglades Restoration Program (CERP), Acceler8 and Fast Track projects begin implementation in 2009. The project is being conducted under an expedited time frame with the approval of a revised regulation schedule and supported by a Supplemental Environmental Impact Statement, is expected by December 31, 2006 with implementation planned for January 1, 2007. Alternative regulation schedules will be evaluated against performance measures that were developed as part of the Comprehensive Everglades Restoration Program – **RE**storation, **CO**ordination, and **VER**ification (CERP- RECOVER). Each alternative evaluated will include temporary forward pumps as a component in the event of extreme low lake stages.

Prior to the modeling efforts being conducted by the USACE, regional meetings were held to gather public input, which resulted in a total of 11 alternatives/sensitivity runs being modeled initially, integrating both public input and agency participation.

Each PDT member agency selected their recommended alternatives, based on the approved set of Performance Measures, to be advanced into the study's final array of alternatives for full evaluation. Their recommendations were based on overall system wide benefits including estuaries, Lake Okeechobee, Water Quality Everglades/Water Conservation Areas, Water Supply–Lake Okeechobee Service Area (LOSA), Lower East Coast Service Area (LECSA), snail kite habitat, Herbert Hoover Dike integrity, and navigation effects.

The selection of a TSP (Tentatively Selected Plan) is scheduled for May, 2006, following a final evaluation of the physiographic area performance measures as compared with the 2007 base run. Four public meetings will be held during the summer of 2006 following the release of the SEIS (Supplemental Environmental Impact Statement), scheduled for completion by July 15, 2006. Concurrently, a revised Water Control Plan (WCP) is also being released for a public review period, with the final approval of the WCP and SEIS due in December 2006, for a January 2007 implementation.

NOTES

LAKE OKEECHOBEE SUBMERGED AQUATIC VEGETATION, A SHORT AND DYNAMIC RECENT HISTORY

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The areal distribution, density and species composition of submerged aquatic vegetation (SAV) in the pelagic-littoral fringe zone of Lake Okeechobee has been monitored on a regular basis by several different methods since 1999. During this time period the lake has undergone a series of major physical perturbations ranging from a managed recession followed by a severe and prolonged drought to several years of above average rainfall, and 2 successive years of major hurricane impacts. These management and climactic events have resulted in seiches and related wind and wave events, wide fluctuations in lake levels, changes in nutrient loading, and reductions in water column transparency. During this time period SAV coverage has varied from a high of more than 54,000 acres in 2003 to a low of less than 11,000 acres at the end of the growing season in 2005. The relative abundance of individual species has also varied widely from year to year. This paper attempts to relate the observed changes in SAV distribution and species composition to some of the specific climatic events, and changes in hydrologic, and water quality conditions that have characterized Lake Okeechobee during the past 6 years.

NOTES

HYDROLOGIC INFLUENCES ON THE SPATIAL AND TEMPORAL DYNAMICS OF EMERGENT SHORELINE PLANTS IN LAKE OKEECHOBEE

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The response of rooted shoreline plants to extreme changes in water level, hydroperiod and wind events was evaluated along an 18 km area of Lake Okeechobee's littoral/pelagic interface. During a period of deep flooding (1.5 to 2.0 m) in the late 1990s, shoreline plants commonly developed along well defined elevation gradients and species diversity and spatial extent was low. Exposing shoreline sediments during a drought in 2000 to 2001 stimulated seed germination and the establishment of various plant species across a broad range of elevations. This resulted in a > 300% increase (1,045 ha) in shoreline vegetation and a large increase in species diversity. Following a return to more moderate inundation depths in 2002 and 2003, the areal coverage of shoreline plants remained high; however, there were major changes in species composition. Water depth and hydroperiod are primary factors that influence the distribution and abundance of macrophytes in marsh environments. In Lake Okeechobee, the spatial extent of giant bulrush (*Scirpus californicus*) and other shoreline plants is expected to increase provided inundation depths in the bulrush zone remain less than about 1 m. However, extreme drought conditions (lake stage < 3 m NGVD) should be avoided to protect sensitive plants from desiccation.

NOTES

RECENT DEVELOPMENT OF SUBMERSED AQUATIC VEGETATION IN LAKE APOPKA

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Prior to 1940, Lake Apopka was a popular central Florida destination for recreation. The lake was famous for clear water, and abundant game fish. Anecdotal information indicates that Illinois pondweed, *Potomogeton illinoensis,* and eel grass, *Vallisneria americana,* covered most of the lake bottom at that time. After receiving years of agricultural discharges and other nutrient inputs, the lake experienced its first chronic algal bloom in 1947. As the water quality in Lake Apopka continued to decline, due primarily to an increase in total phosphorus (TP), the lake's once abundant submersed macrophytes were shaded out and declined rapidly in just a few years' time. The *Potomogeton* and *Vallisneria* beds disappeared and remained absent for decades.

The St. Johns River Water Management District (District) began restoration efforts on the lake in 1985 after passage of the Lake Apopka Restoration Act by the Florida legislature. The first significant decrease in TP, and increase in water clarity, occurred in 1995. At that same time, new beds of volunteer *Vallisneria* were observed growing in the lake. Over the next four years, numerous *Vallisneria* beds were found in locations around the shoreline of Lake Apopka and were delimited using Global Positioning Systems (GPS). The data were converted to the Geographical Information System (GIS) for additional mapping. In 2000, 77 *Vallisneria* beds were mapped with a total acreage of 6.2 acres.

Because of a regional drought, lake stage dropped below the minimum desirable elevation in March 2000, and record low levels were reached in 2001 and 2002. Lake Apopka lost 75% of its mean lake volume, and mean water depth fell from 1.6 m to 0.45 m. The previously-mapped *Vallisneria* beds became dry during the drought, or impossible to find through the thick growth of terrestrial plants that typically became established in the exposed areas of the lake bottom. New stands of cattail, *Typha spp*., flourished. As the lake water level returned to normal in 2003, *Typha,* along with other emergent plants and trees, formed large floating tussocks that caused localized damage to the remaining beds of desirable wetland plant species.

Although water in Lake Apopka evaporated during the drought and salinities increased, TP remained at a lower level than during previous decades. Three separate hurricanes struck the area in 2004, resulting in a short-term increase in phosphorus levels in the lake. Water column phosphorus quickly decreased, however, and fell to an all time low in the fall of 2005, with a TP level of 59 parts per billion. Along with a decline in TP, chlorophyll levels and turbidity also decreased, while the transparency of the lake water increased. In summer 2004, approximately one year after the lake elevation returned to pre-drought conditions, submersed aquatic vegetation once again began growing in the lake. Along with *Vallisneria americana,* and *Najas guadalupensis*, non-native *Hydrilla verticillata* was observed in many areas of the lake.

District staff have begun an aggressive monitoring and herbicide treatment program to combat *Hydrilla* in Lake Apopka. Desirable native vegetation continues to expand in both numbers of beds and area covered. Fall 2005 numbers of volunteer *Vallisneria americana* beds numbered 195, with a combined acreage of 2.45 acres. Recent monitoring work indicates that the existing beds continue to expand and new beds are frequently discovered.

In addition to monitoring submersed macrophytes in Lake Apopka, the District is also monitoring the Apopka-Beauclair Canal and Lake Beauclair. The Lake Apopka Marsh Flow-Way has been operational for over two years and, during normal weather conditions, its clear, treated water now supplies Lake Apopka's discharge to the downstream Lake Beauclair. Due to a dramatic increase in water clarity, there has been a positive response in growth of submersed aquatic vegetation in the Apopka-Beauclair Canal and Lake Beauclair. Submersed plants have been mapped and *Hydrilla* control is ongoing in these locations as well.

The increases in submersed plant beds that have returned since the District began restoration efforts are proof that the current conditions in many areas of Lake Apopka are adequate for submersed plant re-establishment. The evidence we present suggests that, as the water in the lake and downstream canal and lakes continues to improve, submersed plants will expand following decades of absence during poor water quality and drought conditions.

NOTES

USING GIS TO MAP AREAS OF POTENTIAL SUBMERGED AQUATIC VEGETATION (SAV) RE-ESTABLISHMENT IN LAKE OKEECHOBEE, FL

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Lake Okeechobee is a shallow, eutrophic lake located in south central Florida. It serves as a source of water for agricultural needs, drinking water supply, flood control, and sustains a multi-million dollar fishery. Submerged aquatic vegetation (SAV) provides critical spawning and foraging habitat for the lake fishery and the South Florida Water Management District (SFWMD) has been monitoring SAV within the lake since 1999. Because Lake Okeechobee is very shallow and has large areas of bottom with easily disturbed sediments, it is often impacted by wind events that resuspend bottom sediments into the water column. This resuspension causes increased turbidity in the water column and decreased light penetration to the bottom. During the past two years bottom sediments have been continually resuspended by three hurricanes and seasonably high winter winds. The continual resuspension of inorganic sediments has resulted in a dramatic increase in turbidity and a decrease in water transparency, with water transparency values averaging about 15cm. Concomitantly, there has been a decline in SAV present in the lake. An empirical model was developed that predicts water transparency based on total suspended solids (TSS) samples (used as a surrogate for turbidity) taken at transects around the lake where SAV has been found in the past. This mathematical model was used in conjunction with GIS data layers such as bathymetry and SAV sampling stations to predict areas within the lake that were likely locations for SAV colonization when conditions become favorable based on water depth, light penetration, and TSS values.

NOTES

SESSION 6

NUTRIENT IMPACTS AND CONTROL

FLOATING WETLANDS FOR NITROGEN CONTROL IN WATER BODIES

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Introduction and Purpose

The effectiveness of wetlands for removing nitrogen (N) from surface waters and wastewaters is well documented. Wetlands typically support both oxic and anoxic microenvironments, making them an ideal system for removing N via sequential nitrification and denitrification reactions. The recognized ability of wetlands to improve water quality has led to the promotion of macrophyte plantings in the littoral regions of ponds, lakes and wet detention ponds. Not all water bodies, however, are amenable for littoral plantings. In some cases, the system bathymetry is such that there is limited littoral shelf available for emergent macrophyte beds. In other systems, particularly wet detention ponds, water stages can vary markedly, thereby either flooding the littoral vegetation during high stages, or stranding the macrophytes on dry soil during low stages. Even in water bodies with fairly consistent stage conditions, hydraulic exchange between the vegetated littoral region and the bulk water column may be limited. Finally, in some water bodies, property owners object to littoral plantings for either aesthetic reasons, or concerns that the vegetation could harbor dangerous wildlife. Because of these potential limitations to the use of littoral vegetation, we tested an alternative approach for promoting N removal, in which we cultured macrophyte vegetation in a floating wetland deployed in a small lake.

Study Location and Methods

The floating wetland was deployed in Lake June, a 1.6 hectare, eutrophic urban lake in Orange Co., FL. The wetland was contained within a floating boom and flexible skirt that effectively isolated a column of water $262m^2$ in area and 2.75m deep. To initiate development of a floating vegetative mat, we first encircled an existing stand of *Eichhornia crassipes* in the lake into a floating boom. Other plants were added to create a more diverse wetland, including plants in the genera *Hydrocotyle*, *Bidens*, *Sagittaria*, and *Pontederia*. No vegetation harvesting from the wetland was performed during the study. The wetland was equipped with a solar-powered pump, which provided approximately one hydraulic exchange per week. The system was operated for 20 months, during which time removal of N species, phosphorus (P) species and other water quality constituents was periodically quantified. This presentation focuses only on performance of the system for N removal. Data on the removal of P, and other constituents, is presented in DeBusk et al (2005).

Results and Discussion

Inflow and outflow analyses of the floating wetland over six months revealed that mean total N levels were reduced from 1.80 to 1.08 mg/L, representing a mass removal rate of 0.3 gN/m^2-day. Little nitrate + nitrite-N (NO_x-N) was present in either the wetland inflow or outflow waters. The bulk (94%) of the influent N was organic-N (i.e, probably phytoplankton), and wetland outflow N consisted of both organic-N (70%) and ammonium-N (30%). Near the end of our evaluation period, we turned off the water pump and performed two batch incubations in which we injected NO_3-N into the water column beneath the floating plant mat at concentrations of 4.4 and 8.8 mg/L. During both incubations, NO_3-N levels were reduced to below 0.004 mg/L within 11 days, representing a maximum NO_3-N removal rate of 2.2 gN/m^2-day.

These data demonstrate that denitrification in floating wetlands occurs rapidly, probably due to the prevailing anoxic conditions and ample carbon source availability from decomposing phytoplankton and macrophyte detritus. In the Lake June wetland, nitrification probably limited the availability of NO_3-N for denitrification. Internal compartmentalization of the floating wetland to encourage mineralization, nitrification and denitrification in separate regions may be an effective means of improving floating wetland N removal performance. Different environmental conditions, such as diffuse aeration supplied to the nitrification compartment, could be provided to accelerate sequential N removal processes. Such a compartmentalized floating wetland system should prove useful for removing N from small water bodies in both urban and agricultural settings.

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NOTES

EFFECTS OF INCREASED PHOSPHORUS LOADING ON DISSOLVED OXYGEN IN A SUBTROPICAL WETLAND, THE FLORIDA EVERGLADES

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The Florida Everglades is a network of phosphorus (P)-limited oligotrophic marshes that is experiencing eutrophication as a result of P-enriched agricultural runoff. Effects of P enrichment on diel dissolved oxygen (DO) profiles were measured along nutrient gradients produced by runoff into two Everglades marshes and in field enclosures (mesocosms) subjected to experimental P enrichment. The study areas included transects through Water Conservation Area (WCA) 2A and the Loxahatchee National Wildlife Refuge with the mesocosms located in the unenriched reference area of WCA 2A. Strong diel DO fluctuations and aerobic conditions characterized nutrient-poor areas of the marshes, whereas dampened diel fluctuations and prolonged periods of anoxia were common in enriched areas. Oxygen concentrations in P-enriched mesocosms declined progressively with time and were significantly lower than in unenriched mesocosms after 3 years. Diel oxygen data from each marsh station and mesocosm loading treatment were summarized as cumulative distribution functions to show overall differences in DO concentration patterns among sampling locations. In both the marsh and the mesocosms, reductions in water-column DO with enrichment were associated with a decline in periphyton and submerged macrophytes and an increase in sediment oxygen demand. Increases in floating and emergent macrophyte cover caused by enrichment may have contributed to lower DO through shading, which inhibited submerged productivity, and the production of nutrient-rich detritus, which increased oxygen demand. Multiple statistical analyses were employed to identify differences in trophic classes on the transects and loading treatments in the mesocosms. While oxygen concentrations in wetlands generally are lower than in lakes and rivers, declines in water-column DO can be ecologically significant and result in adverse biological impacts. The use of these diel DO investigations in the marshes of lake littoral zones may provide valuable information for the evaluation of lake health.

NOTES

CARBON DIOXIDE LEVELS AND EMISSIONS FROM FLORIDA LAKES

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Annual rises in atmospheric carbon dioxide (CO_2) have generated worldwide concerns because increases in atmospheric CO_2 contribute to what we know as the greenhouse effect, or warming of the earth's atmosphere (global warming). Much of the focus to date has been on additions of CO_2 coming from human activities, but there are natural sources of CO_2 to the atmosphere. The atmosphere, terrestrial biosphere, oceans, and sediments all serve as carbon reservoirs. The carbon reservoirs are connected through pathways of exchange regulated by various geochemical processes. Because freshwater only covers about 2% of the earth's surface, many scientists have lumped inland freshwater systems (lakes, rivers, streams, reservoirs) with the terrestrial biosphere, or ignored these reservoirs all together, disregarding them as simple pathways to another reservoir. Recent research by Kling et al. 1991, Hesslein et al. 1991, Cole et al. 1994, 1998, and Prairie et al. 2002, however, indicated lakes could be an important source of CO_2 to the atmosphere. In the past decade however, many researchers support the idea that organic matter can either be mineralized or lost as CO_2 to the atmosphere (Cole et al. 1994, 2000; Richey et al. 2002; Sobek et al. 2003; Striegl et al. 2001). When the level of carbon dioxide within a water body exceeds the amount of carbon dioxide present in the atmosphere (supersaturation), the water body then becomes a carbon source (Schindler et al. 1975, Bower and McCorkle 1980, Kling et al. 1991, Hesslein et al. 1991, Cole et al. 1994, 1998).

We present data on 667 lakes distributed throughout the state of Florida. Partial pressure carbon dioxide (pCO_2) levels were calculated for each lake to determine if these lakes are sources of CO_2 to the atmosphere. A total of 667 lakes were sampled from 1979 to 1996. Lakes were sampled between 1 and 48 times in the 17-year period. Carbon dioxide concentrations were computed using averaged pH, total alkalinity, and specific conductance values from the data set for each lake (Cole et al. 1994, Prairie et all 2006). We examined how various chemical and limnological characteristics of these lakes are correlated to varying levels of carbon dioxide. Partial pressure carbon dioxide (independent variable) was correlated with two groups of variables. The first group consisted of trophic state parameters including total phosphorus (TP), total nitrogen (TN), Chlorophyll a and Secchi measurements. The second group was composed of several anions and cations. Pairwise correlation analysis was done using JMP 4.0 SAS Institute Inc. Variables were log transformed to normalize distributions and remove heteroscedasticity. An α value of 0.05 was used.

The partial pressure carbon dioxide level (pCO_2) values for the lakes exhibited a large range (below zero to 915,897 µatm). The average pCO_2 was 12790 µatm. This is more than 30 times the amount of CO_2 present in the overlying atmosphere (~370 µatm). We found 80% of the lakes to be supersaturated with carbon dioxide. Significant pairwise correlations were found for each variable with $logCO_2$. Trophic state indicators (TP, TN, Chlorophyll a) are negatively correlated with pCO_2. All anions and cations with the exception of iron had an inverse correlation with pCO_2. We also see an inverse correlation between conductivity as a whole with pCO_2.

From the data we conclude that Florida Lakes have the potential to be a source of carbon dioxide to the overlying atmosphere. This should be considered to researchers estimating carbon budgets both regionally and globally. This could change our ideas on carbon sources and sinks. Even though freshwater covers only 2% of the earth's surface, we should consider these bodies of water to be potential sources of carbon dioxide, instead of assuming they are sinks for carbon. Our correlations indicate that there exists a inverse relationship between trophic state indicators and levels of pCO2 in this subset of Florida lakes. Trophic state indicators may be an indicator of supersaturation.

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NOTES

TMDLs AND BMAPs AS TOOLS FOR PROJECT IMPLEMENTATION

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The Total Maximum Daily Load (TMDL) Program is an important tool for anyone considering projects affecting potentially impaired waters. Through the program, the Florida Department of Environmental Protection (FDEP) verifies waters as being impaired according to criteria contained in Florida's Identification of Impaired Surface Waters Rule, Chapter 62-303, Florida Administrative Code. These waters are placed on FDEP's 303(d) Verified List, which is submitted to the Environmental Protection Agency pursuant to section 303(d) of the federal Clean Water Act.

The verification of impaired waters is part of the five-phase TMDL cycle (Table 1). On a rotating schedule, the FDEP evaluates five groups of river basins throughout the state (Table 2), identifies the impaired waterbodies in each basin, and develops TMDLs for those waterbodies. A TMDL is the amount of a given pollutant that a waterbody can assimilate and maintain its designated uses. The FDEP then works with affected stakeholders to implement the TMDLs, sometimes through developing a Basin Management Action Plan (BMAP). The existence of TMDLs can provide the impetus for new projects or increased regulations where they are needed most.

TABLE 1. PHASES OF THE TMDL CYCLE

PHASE 1	Preliminary Evaluation of Water Quality
PHASE 2	Strategic Monitoring and Assessment to Verify Water Quality Impairments
PHASE 3	Development and Adoption of TMDLs for Waters Verified as Impaired
PHASE 4	Development of Management Actions to Achieve the TMDL
PHASE 5	Implementation of TMDL(s), including monitoring and assessment

TABLE 2. MAJOR HYDROLOGIC BASINS BY GROUP AND DEP DISTRICT OFFICE

DEP District	***Group 1 Basins***	***Group 2 Basins***	***Group 3 Basins***	***Group 4 Basins***	***Group 5 Basins***
NW	Ochlockonee-St. Marks	Apalachicola-Chipola	*Choctawhatchee-St. Andrews Bay*	Pensacola Bay	Perdido Bay
NE	Suwannee	Lower St. Johns		Nassau-St. Marys	Upper East Coast
Central	Ocklawaha	Middle St. Johns	Upper St. Johns	Kissimmee	Indian River Lagoon
SW	Tampa Bay	Tampa Bay Tributaries	Sarasota Bay-Peace-Myakka	Withlacoochee	Springs Coast
South	Everglades West Coast	Charlotte Harbor	Caloosahatchee	Fisheating Creek	Florida Keys
SE	Lake Okeechobee	St.Lucie-Loxahatchee	Lake Worth Lagoon-Palm Beach Coast	Southeast Coast Biscayne Bay	Everglades

The FDEP has already established many TMDLs within the state, including TMDLs for total phosphorus for ten waterbodies in the Upper Ocklawaha River Basin (UORB), an 878-square mile area located in Central Florida that includes Lake Apopka and the Harris and Clermont Chains of Lakes. As a Group One basin, the UORB will be the first basin to have a statutorily authorized BMAP, to be adopted by FDEP secretarial order. A Basin Working Group (BWG), with members representing about 30 agencies and organizations throughout the UORB, has worked collaboratively on developing the BMAP. It contains completed, ongoing, or planned projects that varyingly affect total phosphorus loads to the ten impaired waters.

Based on modeling conducted by the St. John's River Water Management District (SJRWMD), loading from Lake Apopka muck farms was the greatest single source of total phosphorus within the entire UORB during the period between 1990 and 2001. Muck farms contributed about 117,000 pounds of total phosphorus per year to Lake Apopka. This represents approximately one third of all total phosphorus entering the ten impaired waters from either controllable or uncontrollable sources.

The St. Johns River Water Management District (SJRWMD) has already significantly reduced the amount of total phosphorus discharges to Lake Apopka by eliminating active agricultural loadings though acquisition and ongoing restoration. The SJRWMD expects these efforts to eventually achieve the 55 ppb TMDL total phosphorus target concentration goal for the lake. Lake Beauclair, located immediately downstream of Lake Apopka, has a significantly more restrictive 32 ppb target TMDL concentration for total phosphorus. Consequently, it was clear to BWG members that additional efforts would be necessary to achieve TMDLs downstream of Lake Apopka.

The Lake County Water Authority has proposed a Nutrient Reduction Facility (NuRF) to work collaboratively with SJRWMD efforts to help achieve TMDL goals for lakes downstream of Lake Apopka. The NuRF will use offline alum injection to treat Lake Apopka discharge up to 300 cubic feet per second and reduce downstream total phosphorus loading by an additional sixty-seven percent. The data used in developing the TMDLs and the TMDLs themselves indicate the need for the NuRF, and help justify the expenditure of public funds for its implementation.

The NuRF project is just one example of how the TMDL program can help water management agencies identify or confirm water quality issues and restoration priorities. In the UORB, the projects and activities in the BMAP are anticipated to reduce total phosphorus loadings sufficiently to achieve the TMDLs in four of the impaired waterbodies and come close to the TMDLs in four others. Two of the ten waterbodies (Harris and Trout lakes) will need significant additional reductions to reach their TMDLs. As part of BMAP implementation and follow-up, the BWG will identify other efforts to be undertaken to meet all the TMDL goals in the basin.

FDEP is currently collecting data to further analyze the water quality impairments within the basin, and is working on additional TMDLs for the UORB. This information can be used to direct future efforts aimed at improving water quality in the UORB and eventual delisting of the impaired waters.

NOTES

DESIGN OF THE TAYLOR CREEK ALGAL TURF SCRUBBER® (ATS™) FOR REGIONAL STORMWATER TREATMENT IN THE LAKE OKEECHOBEE WATERSHED

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Regional stormwater treatment systems, in addition to on-site best management practices (BMPs) will be necessary in order to meet total maximum daily load (TMDL) requirements for Lake Okeechobee. HydroMentia's Algal Turf Scrubber® (ATS™) is being utilized as a stormwater treatment technology in the Taylor Creek Basin of the Lake Okeechobee Watershed (LOW).

A $2.7 million pilot project was conducted in the S-154 Basin of the LOW, funded by Florida Department of Environmental Protection (FDEP), Florida Department of Agriculture and Consumer Services (FDACS) and the South Florida Water Management District (SFWMD) during 2002 through 2004. Based on results of that study, a 15 MGD (million gallons per day) Algal Turf Scrubber® Nutrient Recovery Facility is currently being constructed in the Taylor Creek Basin of the LOW, and is expected to be in operation by late 2006.

As part of the pilot project, three, separate ATS™ floways were designed to operate at different linear hydraulic loading rates (LHLR) to determine optimal design conditions for a full-scale regional treatment facility. The pilot units received LHLR of 4.7, 8.5 and 18.8 gallons/min-ft, respectively. Mean removal rates for total phosphorus were 25 g m^{-2} yr^{-1} (223 lbs $acre^{-1}$ yr^{-1}) at the lowest LHLR; 47 g m^{-2} yr^{-1} (419 lbs $acre^{-1}$ yr^{-1}) at LHLR of 8.5 gallons/min-ft and 92 g m^{-2} yr^{-1} (820 lbs $acre^{-1}$ yr^{-1}) at the highest LHLR. Mean influent TP concentration during the study period was 333-336 ppb (HydroMentia, 2005).

Total nitrogen removal rates were monitored as a secondary pollutant of concern for the duration of the study. Removal ranged from 181 g m^{-2} yr^{-1} (1,615 lbs $acre^{-1}$ yr^{-1}) to 722 g m^{-2} yr^{-1} (6,440 lbs $acre^{-1}$ yr^{-1}) with increased hydraulic load. Based on these findings, the Taylor Creek ATS™ was designed with a LHLR of 20 gallons/min-ft.

Nutrient concentrations in the Taylor Creek Basin are similar to those in the S154 Basin, with mean annual total phosphorus concentration of 525 ppb, and total nitrogen concentration of 1.80 mg/l. Based on the ATSDEM model as calibrated for the LOW, projected annual phosphorous and nitrogen reductions are 4,000 lb/yr (1816 kg/yr) and 17,086 lb/yr (7,775 kg/yr), respectively. In developing the model, it is assumed that effluent treatment limits are 40 ppb total phosphorus and 0.70 mg/l total nitrogen.

The Taylor Creek ATS™ is being constructed in an area north of the city of Okeechobee, FL on a property known as Grassy Island. The 15 MGD facility consists of 4.6 acres of process area, with an additional 3 acres of peripheral facilities, including approximately one acre of biomass composting area.

Reference

HydroMentia, Inc. (2005). “S-154 Pilot Single Stage Algal Turf Scrubber (ATS™) Final Report”. South Florida Water Management District Contract No. C-13933.

NOTES

SESSION 7

USE OF ALUM

TREATMENT OF PHOSPHORUS ENRICHED SANDY SOILS IN AGRICULTURAL LAND PRIOR TO CONVERSION TO A CONSTRUCTED TREATMENT WETLAND

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In 2005, the St. Johns River Water Management District constructed a regional stormwater treatment facility (RST), consisting of a 19 acre wet detention pond at the forefront and a 38-acre subsurface wetland. The intent of the RST is to treat nutrient-enriched agricultural runoff within a priority sub-basin of the lower St. Johns River (LSJR) before discharging into Deep Creek, a major tributary. This effort is in support of the 30% nitrogen and phosphorus reductions required for the Tri-County Agricultural Area (TCAA) to meet the Total Maximum Daily Loads as mandated by the Clean Water Act for the Florida Department of Environmental Protection's 303 D listed impaired waters. The facility is designed to treat agricultural runoff from 1,196 acres with a maximum treatment efficiency of 50% total nitrogen and 60% total phosphorus. Approximate annual loading into the RST for nitrogen and phosphorus is 9.21 lb/acre and 4.48 lb/ac, respectively. Agricultural runoff is pumped into the wet detention pond and gravity flows into a header and lateral ditch along the wetland. The wetland hydrologic system is designed to saturate the sandy soils of the wetland laterally through subsurface seepage underlain by a heavy clay layer, mimicking agricultural irrigation practices employed in the TCAA.

The constructed treatment wetland site was formerly used in agricultural production, and thus has the potential to release phosphorus stored in sandy soils upon flooding (Pant et al. 2003). Prior to wetland saturation, soil samples were collected and analyzed for soil test phosphorus (P), iron (Fe), and aluminum (Al) concentrations. Soil test P has historically been used for agronomic purposes, rather than assessment of potential environmental impact; however, studies suggest that soil test P can be used as a tool for assessing the potential for P loss from lands used intensively for agricultural and livestock production (Sharpley et al. 1994; Hyde and Morris 2000; Nair and Graetz 2002; Nair et al. 2004; Novak and Watts 2005). Methods for assessing the environmental risk of P using inexpensive, agronomic soil testing results have been further developed for sandy soils in Florida, where soil test P, Fe, and Al content are analyzed to assess labile P as well as Fe/Al – bound P, typical in Florida sandy soils. These soil test results are variables used to calculate a Phosphorus Saturation Ratio (PSR), indicating the potential for environmental risk by exceeding a defined threshold. Moreover, the soil test results and PSR value are combined to estimate the remaining phosphorus storage capacity of the soil. The Soil Phosphorus Storage Capacity (SPSC) provides a "direct estimate of the amount of P a soil can sorb before exceeding a threshold soil equilibrium concentration," (Nair and Harris 2004) or the point at which the soil becomes a source of P rather than a sink. This method has been used in the Suwannee River basin and the Okeechobee basin on lands intensively used for poultry and dairy operations (Nair and Harris 2004). This same concept was applied to the Deep Creek wetland site within the LSJR basin prior to treatment wetland conversion to assess the potential for internal P loading.

Results of the SPSC value indicated the soil would likely be a source of P rather than a sink within the top 12” of the soil profile. To bind existing P, as well as provide additional binding sites within the soil profile, approximately 25 tons/acre of alum water treatment plant residual was surface applied and incorporated into the top 12” of soil. Results from the first soil sampling event 27 days after alum application indicated the soils had not reached equilibrium, and subsequently there was still a potential to serve as a source of P; however, there was a 95% reduction in the estimated amount of P that could be released from the top 6” surface and an overall 83% average reduction in the top 12”. Interpretation of results and implications for use of the SPSC in this regard will be discussed.

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NOTES

EFFECTS OF LAKE MORPHOLOGY ON THE DURATION OF ALUM APPLICATIONS TO FLORIDA LAKES

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Alum strategies share the common approach of promoting the chemical binding of aluminum with phosphorus at a given ratio of aluminum added. Water column clarification is designed to strip phosphorus and particulates like algae from the water column. On contact with water, alum forms a non-toxic aluminum hydroxide precipitate called floc with high coagulation and phosphorus adsorption properties (Cooke et al., 1986). The settling of the floc through the water column clarifies the water. The efficacy of alum treatments is directly related to the extent of phosphorus complexation which is well documented as dependent on the availability of aluminum, complexing ligands, solution pH, and temperature. The role of lake-morphometry, regarding the duration and cost of in-lake alum treatments for water column clarification, remains largely undescribed. Welch and Cooke (1999) evaluated the effectiveness and longevity of alum treatment for reducing internal phosphorus loading in deep lakes and shallow lakes. They found that many northern lakes in the U.S. have shown significant reductions in algal growth and improvements in water quality for up to 10-15 years following an alum treatment. Poor duration responses were primarily due to low doses, wind mixing, and alum floc interception by plants (e.g., shallow lakes).

Florida lakes are classified as being shallow relative to their surface areas, with the majority of them having mean depths less than 5 m (Florida LAKEWATCH 2003) and thus have the potential for significant sediment resuspension (Bachmann et. al, 2000). Eight Florida lakes that received in-lake alum treatments during 1992-2004 were examined to evaluate the role of surface area, volume, dynamic ratio (√surface area (km2)/mean depth (m)), and mean depth on the effectiveness/duration of an alum application. The duration of alum treatments was also examined in regard to number of applications and season of treatment. Test lakes displayed a wide range of variation in their duration responses ranging from 3 to 60 months. Duration was significantly related to lake volume, lake surface area, and mean depth in seven of the eight lakes. No relationship was observed for duration as a function of the lakes' dynamic ratio. Lake Hollingsworth, a large (355 acre), shallow (<3m) lake, displayed the shortest duration responses and the highest dynamic ratio of 0.9, with a 100% likelihood of resuspension whereas lakes Arnold, Daniel, and Silver exhibited the lowest dynamic ratios of 0.05, 0.05, and 0.11, respectively. These areas had minimal percent areas (6 -15%) subject to resuspension. Even though the likelihood of resuspension in these lakes was slim, these results are still important because other factors including lake-morphometry, storm events, and other applied management strategies can influence the duration of an alum treatment as demonstrated in this study. Florida lakes following an alum treatment did not exhibit the long duration responses (i.e., 10 or more years) reported in the literature for northern lakes. It was demonstrated in this study that a lake's morphometry and its susceptibility for wind-driven resuspension may play a significant role in predicting how a waterbody will respond to an alum treatment. In addition, there are cost-benefit decisions that need to be met by lake managers and residents in Florida. These decisions are tailored and dependent on financial resources and management goals.

NOTES

INTERACTION OF HYPOLIMNETIC ALUM TREATMENT AND IRON CYCLING ON INTERNAL PHOSPHORUS LOADING IN A KETTLE POND

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Ashumet Pond is a 216-acre monomictic, mesotrophic to borderline meso-eutrophic, glacial kettle pond located south of the Massachusetts Military Reservation (MMR), Cape Cod, Massachusetts. The pond is dominated by a large central basin and has a maximum depth of 19 meters. The pond is strongly stratified during the summer and the hypolimnion is typically anoxic with elevated levels of phosphorus, ammonium, dissolved iron and methane from mid June to mid October.

The trophic state of the pond has degraded substantially since 1980, largely due to external phosphorus loading from a wastewater-contaminated groundwater plume originating approximately 2,000 feet northwest of the pond at the former MMR wastewater treatment plant. The phosphorus load entering the pond from this wastewater plume has been estimated to be in the range of 100 to 110 kilograms/year (McCobb 2003). Numerous remedial actions to address the current and potential future effects of the wastewater plume on Ashumet Pond have been evaluated. These efforts culminated in the development of a long-term remedial strategy for the pond consisting of the following three components: (1) reduction of the internal phosphorus load by alum-based phosphorus inactivation of the hypolimnion; (2) long-term reduction of the external phosphorus load by installing a geochemical barrier within the area where the plume discharges to the pond; and (3) long term monitoring of Ashumet Pond water quality.

In September 2001, the first step of the remedial strategy was implemented when a mixture of alum and sodium aluminate was injected at a depth of 35 feet in the pond over a 28-acre area defined by the extent of the anoxic hypolimnion. This "alum" treatment was intended to reduce internal phosphorus loading in the pond, thereby delaying further degradation until a geochemical barrier could be installed to reduce the external phosphorus load from the wastewater plume. The effects of the alum treatment on the pond were evaluated using graphical and statistical techniques to analyze the water column data (e.g., total phosphorus (TP), total and dissolved iron (Fe), light penetration data, Secchi Disk measurements and chlorophyll *a*) collected from 1999 through 2004.

Although modest improvements were noted in water clarity parameters after the 2001 alum treatment, the changes in TP concentrations between 2001 and 2004 were more pronounced. As expected, the concentrations of TP in the anoxic tropholytic zone (10-18 meters) decreased immediately after the alum treatment and subsequently decreased to even lower concentrations during the summer of 2002. Although the total mass of phosphorus in the pond was also substantially lowered by the treatment, the estimated total mass of phosphorus in the pond remained relatively constant at this lower level in 2002, 2003, and 2004. Although the total mass of phosphorus in the pond remained relatively constant, the average concentrations of TP in the productive trophogenic zone (0-8 meters) decreased systematically in each of these years while the average TP concentrations in the anoxic tropholytic zone systematically increased toward pre-treatment levels. These conflicting TP trends suggest that there was a net transfer of TP from the trophogenic zone to the tropholytic zone of the pond during 2002, 2003, and 2004. Analysis of pre- and post-treatment Fe to TP ratios in samples collected from the tropholytic zone during anoxic, iron-reducing conditions, suggests that the progressive reductions in average TP concentrations in the trophogenic zone and the simultaneous increases in average TP concentrations in the tropholytic zone, reflect the progressive trapping of TP in the trophogenic zone and deep basin sediments by the iron cycle. This newly trapped TP appears to be replacing the original pool of TP trapped in the tropholytic zone and deep sediments that was sequestered (post treatment) by aluminum hydroxide and thereby decoupled from the redox-driven iron cycle.

The data collected at Ashumet Pond suggest that aluminum hydroxide introduced into deep basin sediments can interact with the iron cycle in well-stratified lakes and produce a progressive multi-year net transfer of TP from the algae producing trophogenic zone to the relatively unproductive tropholytic zone. In Ashumet Pond this process resulted in the development of progressively lower phosphorus concentrations in the trophogenic zone and progressively higher concentrations in the tropholytic zones from 2002 to 2004. These post-alum treatment trends would likely be absent or much less pronounced in shallow lakes, poorly stratified deep lakes, or of lakes that have iron-poor sediments.

References

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NOTES

SESSION 8

LAKE APOPKA / LAKE OKEECHOBEE – WATERSHED / WATER QUALITY ISSUES

OPERATION AND PERFORMANCE OF THE LAKE APOPKA MARSH FLOW-WAY

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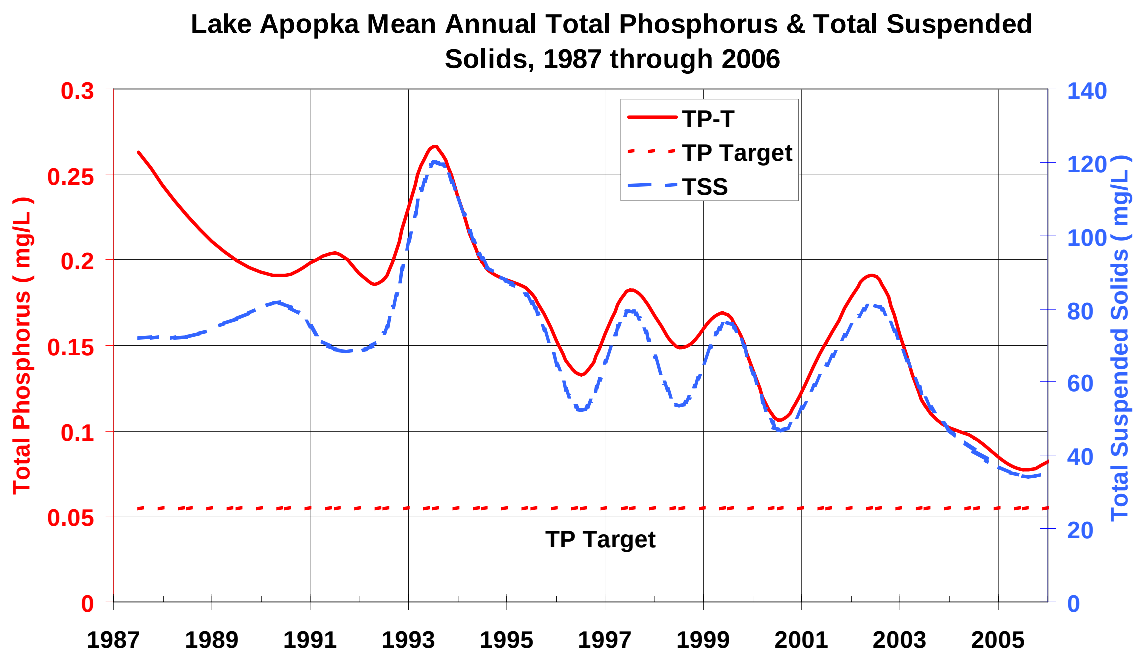
Lake Apopka is a shallow, 125 km^2 hypereutrophic lake northwest of Orlando Florida which has been the focus of restoration efforts by the St. Johns River Water Management District. One component of the multi-part restoration program is the operation of the Marsh Flow-Way (MFW), a recirculating wetland filter designed to remove suspended solids and their associated nutrients from the lake's water and return treated water to Lake Apopka and the downstream Ocklawaha chain of lakes. The particulate phosphorus fraction of Lake Apopka water is 90%, while the particulate nitrogen fraction is 50%. Unlike most treatment wetlands, the MFW is not designed to reduce dissolved forms of nutrients. The system consists of four independent treatment cells with approximately 656 acres of treatment area built on former muck farms on the lake's north shore.

The MFW began operating in November 2003 and has filtered over 215,000 acre-feet, 119% of the lake's volume. Performance has varied with a variety of factors, including inflow nutrient concentration, season (temperature), rainfall and maintenance needs. Design improvements over the Apopka Demonstration Project and the Lake Griffin Flow-Way have increased performance. The Apopka Demonstration Project operated at the same site (1989-1997) and allowed the District to test wetland filtration concepts. The Lake Griffin Flow-Way (1997-2002) operated until phosphorus concentrations in the lake dropped too low for net removal. The District is currently experimenting with low-dose alum injection within the cells to increase PO_4 removal and respond to declining inflow phosphorus concentrations. Although they present an increasing challenge for the MFW, the declining total phosphorus and total suspended solids concentrations in Lake Apopka are indicators of the overall restoration program success.



To date the system has removed over 9,000 metric tons of solids. Cumulative nitrogen and phosphorus removal are 251 and 5 metric tons, respectively. While under farm operation this area would have loaded 7 metric tons of phosphorus over the same time period, thus the MFW net reduction is 12 metric tons of phosphorus. The treated water is first routed to supply the discharge requirements from Lake Apopka to the Ocklawaha chain of lakes with any balance returning to Lake Apopka. Both lakes (Beauclair and Apopka) which receive MFW-treated water are experiencing increased submersed aquatic vegetation abundance, in response to both clearer water and lower overall nutrient loading.

NOTES

AN OVERVIEW OF CURRENT AND PLANNED PHOSPHORUS REDUCTION PROJECTS IN THE LAKE OKEECHOBEE WATERSHED

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In support of the Lake Okeechobee Protection Plan (LOPP), and Lake Okeechobee and Estuary Recovery Program (LOER), numerous phosphorous reduction projects have been initiated with additional large scale projects planned in the Lake Okeechobee Watershed. A series of parcel scale phosphorous reduction programs have been initiated in the watershed through the Isolated Wetlands Program, the Phosphorous Source Control Grant program, and others. These programs have been funded by State Appropriations and are reviewed through an inter-agency team consisting primarily of the South Florida Water Management District (SFWMD), Florida Department of Environmental Protection (FDEP) and the Florida Department of Agricultural and Consumer Services (FDACS). Several regional projects, in addition to the Taylor Creek / Nubbin Slough Stormwater Treatment Areas (STAs), are currently underway which will further serve to reduce phosphorous. These large projects have also been funded through State appropriations.

Some of the watershed projects include: (1) Restoration of isolated wetlands on private and public lands. These projects are designed to increase water detention in remnant isolated wetlands for re-hydration and to reduce phosphorous by detaining water and allowing residence time within the wetland to allow for plant uptake of the phosphorous; (2) Remediation of five former dairies which have either been purchased by the SFWMD or have been converted to beef cattle operations. The remediations consist of Alum treatments within the waste lagoon, soil amendments within the old high intensity areas and reconfiguration of the drainage patterns and stormwater management of the sites to detain more water on site; and (3) dairy BATS (Best Available Technologies) have been implemented at five operating dairies within the watershed. Dairy BATS include chemical treatment of dairy waste water prior to off-site discharge along with increased storage and detention of water on site.

Currently there are two constructed Stormwater Treatment Areas within the watershed; Taylor Creek STA and Nubbin Slough STA. Design is complete for the Nubbin Slough STA expansion which includes additional land for treatment and a force main pump station located to supply a continuous source of water. Basis of design reports and preliminary engineering are proceeding on four additional large stormwater projects within the watershed. These four projects consist of the following: (1) Lakeside Ranch STA, a large STA being constructed on the northeast side of the Lake to capture stormwater runoff and will also have the capacity to treat lake water; (2) Taylor Creek Reservoir, a large reservoir constructed along Taylor Creek to capture water during flow events and store it for later treatment before being released to the lake; (3) S-133 basin and (4) S-154 basin re-routing to change the current flow of stormwater from direct discharge to the lake from these basins and direct them to the Lakeside Ranch STA.

NOTES

USE OF LIQUID ALUM AND ALUM RESIDUAL TO REDUCE PHOSPHORUS LOADING FROM FORMER AGRICULTURAL FARMLANDS

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Water quality and riparian habitat within the St. Johns River Water Management District in North Central Florida declined dramatically over the last century. To reduce nutrient loading to adjacent waterbodies and to restore aquatic, wetland, and hydrologic functions, the District has acquired more than 34,000 acres of former agricultural lands in the Upper Ocklawaha River Basin, which includes the Lake Apopka basin. The organic soils on these sites are a significant potential source of phosphorus (P) pollution. Once reflooded, the P concentrations in these wetlands can take decades to decline to levels low enough to discharge back to adjacent water bodies without resulting in excessive loading. Various chemical amendments and application strategies have been tested or implemented as alternatives to reduce phosphorus flux from the soils. Although chemical treatment has been successful in lake restoration programs, large-scale soil amendment application in wetlands for phosphorus immobilization has not been done.

The District has undertaken a two-pronged approach to treating these sites. Within the Lake Apopka basin, approximately 13,000 acres were in a dry condition following the conclusion of farming. These areas will be treated with alum residual, a by-product of the drinking water process. Approximately 4,200 acres have already been treated with alum residual prior to reflooding.

In former farms that have previously been flooded, various methods of liquid alum application have proven successful including “in-lake” application by barges including spray application from airboat and MarshMaster™. Barge applications have been utilized on all or parts of six former farms covering over 3,000 acres. Spray applications have been less successful in heavily vegetated wetlands due to the tendency of the alum to remain on the plants.

Most recently, flow proportional injection to discharge waters has been used widely throughout the basin. At this time, most discharges from District properties were treated with liquid alum. For instance, discharges from a 2,000 acre area west of the Apopka-Beauclair Canal were treated in 2005. Storm events from 2004 and 2005 had created elevated water levels within the area, which threatened adjacent landowners and the integrity of project levees and pumps. The untreated discharge of six inches of water off this area would approximately equal the P loading that the District has allocated to this property in a full year. To treat the discharge and reduce P loading, a temporary alum injection system was designed and constructed. One of the cells of the Marsh Flow-Way was utilized to capture the alum floc prior to discharge back to Lake Apopka. The system operated for 272 days during 2005 and reduced potential P loading by over 1.5 metric tons. Over 7,100 acre feet of water were treated with an average alum dosage of 12-15 mg Al/L. The advantage of this temporary, mobile system, which utilized a photovoltaic system to power the alum dosing pumps, is the ability to treat multiple sites without the benefit of electrical hookups. The injection system was relocated in 2006 to the former Duda Farms.

The restoration of former agricultural lands is a complex and lengthy process. Water treatment residuals and liquid alum can be used to cost-effectively reduce the influence of impacted areas on the surrounding ecosystem and shorten the restoration timeline.

NOTES

IMPACT OF GIZZARD SHAD REMOVAL ON NUTRIENT CYCLES IN LAKE APOPKA, FLORIDA

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The removal of benthic-feeding fishes has been used by lake managers as a tool to improve water quality in many shallow eutrophic systems. Removing benthic fish can remove nutrients contained in fish tissues and also can prevent substantial amounts of nutrient release via excretion (Lamarra 1975, Brabrand et al. 1990, Schaus et al. 1997), which can impact phytoplankton abundance (Schaus and Vanni 2000). By feeding on benthic materials, gizzard shad can transport nutrients from sediments into the water column via their excretion, unlike planktivores, whose excretion recycles nutrients within the water column (Vanni 2002). Thus, lake nutrient cycles may be substantially impacted by biomanipulation efforts.

In order to improve the water quality of Lake Apopka, the St. Johns River Water Management District (SJRWMD) has cut external nutrient inputs and has removed >5,400,000 kg of gizzard shad from this system since 1993. Gizzard shad were removed through an intensive offshore gill net harvest targeted at this species. To better understand the impact of this biomanipulation on lake nutrient cycles, we measured nutrient excretion of 243 field-collected gizzard shad between June 2004 and August 2005 across the range of fish sizes and temperatures typically observed in this system.

Excretion of nitrogen (N) and phosphorus (P) showed significant positive correlations with lake temperature and fish size, similar to previous studies (Schaus et al. 1997, Gido 2002). N excretion was most strongly influenced by fish mass, although it was somewhat temperature dependent. In contrast, P excretion was much more strongly affected by lake temperature, thus the P excretion varied substantially across months with much higher excretion during summer months. As a result, the mean N:P of excretion was lowest during summer, and higher in winter and spring.

By using excretion rates of gizzard shad >200g (i.e., those susceptible to harvest using gill nets), we estimated that the nutrient release prevented by a typical annual harvest (454,000 kg) was 2820-5040 kg N/month, and 190-1830 kg P/month. On an annual basis, 454,000 kg of gizzard shad >200g would recycle 47,967 kg of N and 11,504 kg of P. Across years, the nutrient excretion prevented by the biomanipulation efforts varied substantially due to variations in annual fish harvest. During years with high gizzard shad harvest, the amount of P release prevented exceeded 2000 kg of P per month during the summer months. Since its inception, the gizzard shad harvest has removed over 38,500 kg of P in fish tissues and prevented the release of over 144,000 kg of P via excretion.

It appears that this fish harvest has had substantial effects on lake nutrient cycles, as the fish harvest has prevented fish from translocating large amounts of N and P from lake sediments to the water column. The magnitude of this effect (mean reduction of 11 mt P yr^{-1}) is smaller than the overall reduction in external P loading (37.5 mt P yr^{-1}). However, the P that is prevented from being excreted by gizzard shad harvest greatly exceeds the current external P load during dry years. In addition, the reduction in P excretion during years of high gizzard shad harvest (18-21.6 mt P yr^{-1}) is equivalent in magnitude to a typical year's external P loading (18.7-27.2 mt P yr^{-1}).

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NOTES

SESSION 9

CRITTERS – SMALL, MEDIUM, AND LARGE

RELATING OCKLAWAHA BASIN LAKES MACROINVERTEBRATE COMMUNITIES TO WATER AND SEDIMENT CHARACTERISTICS

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In pursuit of its mission to protect, preserve, and manage water resources in northeastern and east-central Florida, the St. Johns River Water Management District (SJRWMD or District) supports studies to determine the quality of surface water resources. SJRWMD is also required to protect, improve, or restore surface waters not currently meeting water quality standards, and maintain native biological diversity and productivity. Contamination of sediments by organic pesticides and heavy metals and eutrophication of waterbodies due to increased accumulation and recycling of nutrients are important management issues related to water quality and associated biological diversity. Benthic (bottom-dwelling) macroinvertebrates can serve as biological indicators of these conditions because they are relatively stationary and unable to avoid environmental stresses caused by pollution.

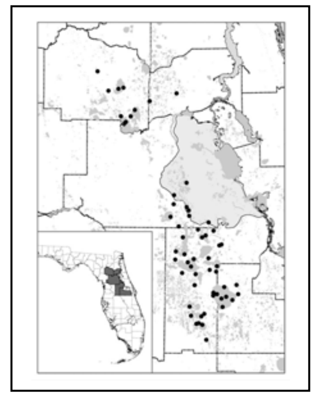

Figure 1. Study Area.

Evans et al. (2004) summarized District-wide macroinvertebrate surveys and demonstrated how benthic macroinvertebrate community composition can indicate the extent of sediment contamination and biological degradation caused by nutrient-induced eutrophication. These studies and previous and subsequent work identified the upper Ocklawaha River Basin as an area of particular concern due to sediment contamination and degraded biological communities (e.g., Ceric et al. 2004; Coventry et al. 2005). This region continues to be a focus of District restoration and research projects. The Florida Department of Environmental Protection (FDEP) has designated Lake Apopka and the upper Ocklawaha River Basin as Surface Water Improvement and Management Program Priority Waterbodies (FDEP 2005; SJRWMD 2003). The most recent project was focused on assessing benthic macroinvertebrate communities of Ocklawaha River Basin lakes in relation to water quality and sediment contamination.

Macroinvertebrate samples were collected from 58 randomly selected lakes in the Ocklawaha River Basin, which consists of the mainstem Ocklawaha Basin Lakes (with Lake Apopka as the headwater) and the Orange Creek Basin, originating north of Newnans Lake, east of Gainesville. Lakes sampled were equally divided among small lakes (area < 10 hectares) and large lakes (area > 10 hectares). Four replicate samples were collected per site by SJRWMD with 232 total petite Ponar replicates analyzed. Water & Air Research personnel sorted the samples, made slide mounts, and performed macroinvertebrate identifications. Data were entered into a database, compiled to spreadsheets, and a suite of macroinvertebrate metrics was calculated. Select physical and environmental data were also collected and compiled. All phases of these operations were subject to rigorous QA/QC procedures.

Conventional, non-parametric, and multivariate statistical procedures were applied to identify relationships between macroinvertebrate metrics and physical data, and to identify exceptional lakes. The Augmented Florida Index was found to be negatively correlated to water nutrient concentrations. This was a highly significant statistical relationship. Sediment nutrient concentrations were found to explain the occurrence of some groups of macroinvertebrates, and were significantly related to several macroinvertebrate metrics. Measurements of sediment nitrogen and phosphorus levels may be useful as a cost-effective screening tool for characterizing a lake's trophic status and for assessing its potential to support a healthy and diverse benthic fauna.

Several environmental parameters and macroinvertebrate metrics for large lakes were found to be significantly different from those of small lakes. Large lakes were characterized as eutrophic as a group, while small lakes were found to be oligotrophic as a group. Data and findings from this study will be used to guide District management decisions regarding these lakes. A thorough report detailing findings and methods was prepared by Water & Air Research, Inc. for SJRWMD (Strom et al. 2005).

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NOTES

THE STRUCTURE OF THE ZOOPLANKTON COMMUNITY RELATIVE TO TROPHIC STATUS IN THREE CENTRAL FLORIDA LAKES

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Purpose, Scope and Objectives: Freshwater zooplankton consist of free-floating or feebly swimming members of the animal kingdom that reside, feed, and reproduce in the pelagic and/or littoral zone of water bodies. In Florida, this community has been described in oligotrophic (Billets and Osborne, 1985), mesotrophic (Nordlie, 1976), and eutrophic (Osborne and Egan, 1997) lakes; in acidic lakes (Jansen and Osborne, 1993; Lamia, 1987); as affected by aeration (Cowell, et al., 1987); as affected by weed control (Fry and Osborne, 1980; Schmitz and Osborne, 1984; Richard, et al., 1985) and as related to trophic state (Blancher, 1984; Young, 1979). As a group, zooplankton have not been extensively utilized as a monitor of water quality or trophic state due to the thought that zooplankton, which are opportunistic, are relatively insensitive to environmental alterations (Kocksiek, et al., 1971). Even so, it has been noted that shifts have occurred within the rotifer component (Aroa, 1964) and between calanoid copepod species, i.e. *Diaptomus spp.* (Elmore, 1983) as a result of eutrophication.

The purpose of this paper is to describe and compare the zooplankton community in three lakes of different trophic state (oligotrophic, eutrophic and hypereutrophic).

Methods: Vertical tow net hauls were taken with a #20 mesh nylon plankton net to sample Spring Lake (eutrophic) and Lake Seminary (oligotrophic), while oblique tow net hauls with a similar mesh size net were used to collect zooplankton from Lake Jesup (hypereutrophic). Monthly collections were taken throughout 2003. Zooplankton were counted from within triplicate sample aliquots of 1 ml that were obtained with a Hensen-Stempel automatic pipette after samples were adjusted to 100 ml and placed into a round-bottom flask. The strip-count method (Sedgwick-Rafter counting cell) was used to enumerate the zooplankton to the species level at magnifications of 100x, 200x, and 400x, using either a compound microscope or stereomicroscope. After enumeration and averages for subsamples were obtained, species abundance was expressed as the number of individuals/liter.

Results and Discussion: Of the 54 species of rotifers and microcrustaceans collected from the three lakes, only 17 species were found common in all three lakes. More species were common between the eutrophic and hypereutrophic lakes than between the oligotrophic lake and the eutrophic-hypereutrophic lakes. Lake Jesup and Spring Lake contained the highest numbers of species and the highest abundance. Rotifers dominated the zooplankton in these lakes. Rotifers made up 77% of all individuals in Spring Lake, and 65.5% in Lake Jesup, but only 21% in Lake Seminary. Cladocerans were obviously absent in Spring Lake and Lake Jesup, making up only 4% of the zooplankton abundance in eutrophic Spring Lake and just 0.5% in hypereutrophic Lake Jesup. Only 1 cladoceran species/L (annual mean) was found in Lake Jesup and Spring Lake, while 5 species/L was calculated for Lake Seminary. A shift from *Diaptomus floridanus* (Lake Seminary) to *Diaptomus dorsalis* (Lake Jesup and Spring Lake) was observed for the calanoid copepods.

Summary: Based upon the comparison of the data collected from our three lakes of different trophic state, it was found that eutrophication resulted in an increase in rotifer species and density (abundance) of rotifers, a general trend for a higher density of copepods, and a significant decrease in cladoceran species and density. The rotifer species, *Brachionus havanaensis* and *Conchiloides unicornus*, and the calanoid copepod specie, *Diaptomus dorsalis*, dominated in the eutrophic-hypereutrophic lakes.

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NOTES

ADULT CHIRONOMID RESPONSE TO DIRECTIONAL LIGHTING ALTERATIONS AT A CENTRAL FLORIDA LAKEFRONT CITY

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Lake Monroe, central Florida, historically produces high abundances of chironomid midges, particularly *Glyptotendipes paripes* and *Chironomus crassicaudatus*, which often emerge in large swarms and congregate at intense lights at the lakeside city of Sanford. A new 1.2-mile Sanford River Walk project was completed in May of 2004, adding approximately 150 decorative lights to the shoreline. Prior to project completion these lights were tested and found to attract twelve times more midges than did the pre-existing streetlights. As installed, each River Walk light emitted 360º of intense horizontal light. Therefore, a 2005 light study was conducted at the completed Sanford River Walk to test the adult *G. paripes* response to directional lighting alterations. Light shields designed to reduce half of the horizontal light were purchased and later installed inside River Walk light globes to potentially minimize the attractiveness of a designated shoreline area to emerging chironomids. In the study, *G. paripes* adults were collected and counted at River Walk lights in both shielded and unshielded shoreline areas from May through November of 2005.

Preliminary measurements were initially taken and sticky sampling panels were constructed and adjusted for adult collection. The entire 1.2-mile River Walk was first evaluated for potential control and experimental test areas which reflected consistent and near equivalent pre-shielding midge attraction. Varied light activation timing, physical barriers, and competing lights in the area were noted as major influences upon collections and were intentionally avoided to reduce potential study biases. Optimal study conditions were eventually met and major study data were then collected within a 0.6-mile stretch of the River Walk from June 17 to October 19, 2005.

The selected 0.6-mile stretch of River Walk was subdivided into two designated 0.2-mile test areas with about 0.2 miles of shoreline separating the two. Each of the two test areas consisted of 13 total lights: 7 path lights (globes stand straight up) and 6 streetlights (globes hang down). One 16 x 16 inch sticky sampling panel was attached to each of the three center path light poles per area (total of six poles with panels) for trapping adult midges during each sampling period (from about dusk to dawn). Midges were then collected and counted from the panels on nine occasions from June 17 to July 17, 2005 and a mean pre-shielding ratio value was established. Also, on July 14, 2005, a hand-held light meter was used to quantify light intensity of the test areas from the lake at 5, 15, 25, and 60 meters from the center path light in both the control and experimental areas before shields were installed.

The light-filtering shields were then installed inside the globes of all 13 lights in the experimental area. The shields were positioned to filter half (180º) of horizontal light to minimize the light intensity specifically directed toward the lake. Also, two sticky panels were added in each area to sample 5 path lights in each area (total of 10 sampled light poles) during the post-shielding portion of the experiment. After installations were complete, the midge data collection resumed from July 28 to October 19, 2005 on twenty more occasions. On August 31st, a post-shielding light intensity survey was conducted using the same procedure as the pre-shielding survey performed on July 14th. Then, all collection data were tabulated and statistically analyzed using Microsoft Excel and Graph Pad Instat. Enumerated adult values were reduced to ratio numbers to analyze the control versus experimental values for each collection period independently from one another before data were summarized as a single mean percent reduction value.

According to resulting data, the number of *G. paripes* adults was reduced by 42% after shields were installed. A 1:1 mean ratio of *G. paripes* found before shielding improved to a 1.7:1 mean (unshielded to shielded areas) after shielding (ranged 1:3.6 to 17.0:1; median = 1.4:1). The shoreline light survey revealed a 75% mean light intensity reduction in the experimental area after shielding. The pre-shielding values were 20, 4, 2, and 1 lux at 5, 15, 25, and 60 meters (respectively) from the shoreline lights. The post-shielding values were reduced to 5, 2, 1, and 0 lux at the experimental area while the control area light intensity measured exactly the same during both surveys.

Thus, a mean 75% light intensity reduction seemed to directly support a 42% reduction of adult *G. paripes* to the shielded River Walk lights. The 0.2 miles of shielded lights tested in the experiment may serve as a model representing approximately 17% of the entire 1.2 miles of River Walk shoreline. So a large-scale installation of River Walk light shields has been recommended and will soon be implemented at all applicable lights at Sanford's Lake Monroe shoreline to reduce the potential for high midge nuisance levels on a regular basis. Additionally, favorable light activation timing, physical barrier, and competitive light manipulations are recommended for the City of Sanford to maximize the potential for nuisance chironomid reductions.

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NOTES

BIOACCUMULATION IN FISH OF RESIDUAL ORGANOCHLORINE PESTICIDES FROM FORMER AGRICULTURAL SOILS

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Lake Apopka has been the focus of restoration efforts by the St. Johns River Water Management District (District) since 1985 (Hoge et al. 2003). To reduce phosphorus loading to the lake, the District used state and federal funding to purchase approximately 20,000 acres of riparian farms bordering the lake's north shore, now referred to as the North Shore Restoration Area (NSRA). Following the final large land purchase in the summer of 1998, some of the newly acquired farm properties were flooded, resulting in an unprecedented number of birds visiting the site. By fall 1998 and early winter 1999, a significant bird mortality event occurred and the area was drained. The District and the US Fish and Wildlife Service (USFWS) determined that the majority of the fish-eating birds died from organochlorine pesticide (OCP) toxicosis. Extensive resampling of soils for OCP and total organic carbon analysis was conducted primarily in 1999.

The OCPs of potential concern in the NSRA are toxaphene, DDT (and its metabolites DDE, and DDD), dieldrin, and several chlordane compounds. Chlordane use was banned by the EPA in 1988, and the other OCPs have been banned for over two decades. After consultation with the USFWS, a 2,500-acre portion of the NSRA, with the lowest soil levels of OCPs, was incrementally flooded, beginning in 2002. The property remains flooded and on-going fish monitoring indicates there is no threat posed to fish-consuming birds. However, in order to ensure that wetland development can safely proceed in the remaining, more highly contaminated, areas of the NSRA we must evaluate the risk from OCP residues in the soils. Ecological risk assessments often use a simple environmental fate model that characterizes the bioaccumulation of lipophilic OCPs as a function of organic carbon in sediments and lipid in aquatic organisms (Wong et al. 2001). In these models, bioaccumulation is quantified using Biota Sediment Accumulation Factors (BSAFs). One goal of our on-going research has been to determine site-specific BSAFs for weathered OCPs in highly-organic soils.

A bioaccumulation study was conducted in collaboration with the University of Florida (UF) and the US Geological Survey (Principal Investigator: Timothy S. Gross). Several components to this multi-year study have provided BSAFs. Three mesocosm ponds were constructed on the NSRA at sites representing high, medium and low soil OCP levels. Each mesocosm consisted of three 0.25-acre ponds hydrologically connected, but separated by shade cloth to prevent exchange of fish. The ponds were stocked with crayfish and several species of fish, and operated to simulate the wetland conditions that will develop in the NSRA under shallow flooding. Organisms were removed and analyzed for OCPs periodically. Two additional 0.25-acre ponds were constructed on the NSRA at a site representing high OCP soil levels. These ponds were used to produce fish, primarily tilapia, for a bird feeding experiment at the UF facilities in Gainesville, FL. The fish ponds were maintained at a greater water depth than the mesocosm ponds and remained primarily open water and unvegetated. Beginning in 2002, fish were harvested periodically for the feeding experiments and OCP analyses were performed.

None of the OCPs evaluated showed significant variation in BSAFs with OCP concentration in the soil (linear regression, F-test, $p>0.05$). Crayfish BSAFs tended to be lower (i.e. less OCP accumulation) than those for fish species and BSAF values for all fish species in the mesocosms were similar. However, for the OCPs measured, BSAFs were several-fold lower for fish from the mesocosms than from the fish ponds.

We suggest that the bioaccumulation of OCPs by fish was less in the mesocosm ponds because the emergent vegetation and periphytic primary producers in the shallow ponds provided more new organic matter and vertical structure to support food organisms with lower concentrations of pesticide residues. In contrast, the primary food web in the unvegetated fish ponds was likely based on original soil organic matter with higher pesticide residues.

The apparent difference in OCP accumulation in fish from open-water versus vegetated ponds indicates that to minimize risk to fish-eating birds, restoration efforts should focus initially on creating habitats with emergent vegetation. If deep water (unvegetated) conditions are required for management reasons, remediation of soil OCPs may be necessary at a lower level of contamination than would otherwise be required under shallow-flooded, vegetated conditions.

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NOTES

SESSION 10

MACROPHYTES:
CAN'T LIVE WITH THEM,
CAN'T LIVE WITHOUT THEM

THE EFFECTS OF SHADING ON PISTILLATE *HYDRILLA VERTICILLATA* (L.F.) ROYLE TRANSPLANTS FROM LAKE OKEECHOBEE, FLORIDA, USA

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The effect of shading on morphometric and meristic characteristics of pistillate *Hydrilla verticillata* (L.f.) Royle was investigated in a large outdoor tank using water, sediment, and plants from Lake Okeechobee, Florida. Plants were grown in peat sediment and lake water, under ambient temperature (27 - 31 $^{\circ}$C) and photoperiod (13 L : 11D). Treatments were established by differentially shading plants with varying numbers of layers of fiberglass window screen. Photon flux density (PFD) ranged from 8 to 154 μmole photons m^{-2} s^{-1}, or 1.1 to 21.6 % of average incident photosynthetically active solar radiation (PAR), based on percent transmittance in the tank and averaged continuous daytime measurements from a mid-lake PAR sensor.

Plant characteristics examined included ash-free dry mass, total leaf, internode, shoot, and branch numbers, leaf area, and cumulative shoot length; all of which decreased linearly with decreasing PAR, and had statistically significant treatment effects. No statistically significant treatment effects were found, however, when leaf and branch numbers on the upper third of each shoot were expressed as a percentage of their totals, indicating canopy formation had not yet occurred.

The apparent photosynthetic PFD for no net growth of *H. verticillata*, measured approximately a quarter meter above the sediment surface, approximated zero, with an upper 95% confidence limit of 13 μmole photons m^{-2} s^{-1}, or 1.8 % of mean incident PAR. These results suggest that, *H. verticillata* can grow in very low light, which likely is an important adaptation given the poor light climate typical of this and many other culturally eutrophic waterbodies.

NOTES

SUBMERSED AQUATIC VEGETATION MONITORING IN THE UPPER OCKLAWAHA RIVER BASIN

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Submersed aquatic vegetation (SAV) monitoring has been conducted within lakes Griffin, Harris, and Eustis of the Upper Ocklawaha River Basin during the last 2.25 years to provide an estimate of the coverage and location of native species and an early warning to facilitate treatment of invasive species. Monitoring was initiated after a noticeable increase in SAV extent within the lakes followed recent drought conditions. Low water associated with drought and increased light transmission from improving water quality seems to have promoted the expansion of SAV. Monitoring is conducted by slowly motoring with a small boat along the near-shore environment and recording species occurrence, estimated patch size, geographical position, plant condition, and coexisting environmental parameters (e.g. water depth and sediment description). Results to date have provided insights into species composition, associations, and dynamics. Species observed included: *Ceratophyllum demersum, Chara* spp., *Hydrilla verticillata, Najas guadalupensis, Potamogeton illinoensis, Sagittaria kurziana, Sagittaria* spp., and *Vallisneria americana.* Numerous associations of the species listed above were observed. Water depths ranged from <0.30 m to 2 m. For the two dominant species, associations with bottom sediment included *Hydrilla verticillata* favoring organics (31%) over sand (9%) and Valisneria americana favoring sand (27%) over organics (12%). Locating and reporting *Hydrilla verticillata* has supplemented invasive species monitoring and management activities of the Lake County Aquatic Plant Management Section of the Lake County Environmental Services Department.

NOTES

THE RELATIVE IMPORTANCE OF SUBMERGED AQUATIC VEGETATION FOR NUTRIENT CYCLING IN THE LOWER BASIN OF THE ST. JOHNS RIVER

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Introduction

One of the first steps in understanding an ecosystem is creating a budget representing the pools and fluxes for the nutrients of concern. Nutrient budgets have been created for the Lower St. Johns River Basin (LSJRB) in the course of Pollution Load Reduction Goal (PLRG) and Total Maximum Daily Load (TMDL) calculations. Phytoplankton are an important pool for nutrients in the river and are well characterized with regular water quality sampling allowing relatively accurate estimates of standing biomass. Submerged Aquatic Vegetation (SAV) has been heretofore less well studied in the LSJRB and the monitoring protocols make estimates of standing biomass more tenuous than with phytoplankton. However, we now have sufficient data to be able to estimate system wide SAV biomass and compare the nutrient retention of phytoplankton and SAV. This work builds upon earlier work examining the carbon, nitrogen, and phosphorus contents of several SAV species found in the LSJRB and use those data to estimate nutrient contents in standing biomass.

Methods

Phytoplankton dry weight (DW) was calculated from chlorophyll *a* measurements taken during routine water quality monitoring. Chlorophyll *a* was assumed to be 1% of phytoplankton DW. Elemental composition (nitrogen, N; phosphorus, P) was calculated using data from Elser et al. (2000). SAV DW was estimated using an empirical relationship between categorical cover class and DW. Elemental composition for SAV was calculated using measured elemental content of species collected in the LSJRB (M. Lockwood, unpublished data). This study analyzed annual mean data from 2000 through 2004.

Spatial distribution of phytoplankton was by entering estimates of mean annual DW (gm^{-3}) and interpolating those values within the mainstem of the river. The product of interpolated values and bathymetric values provided areal DW estimates (gm^{-2}). Spatial distribution of SAV was calculated by first segregating the mainstem river area that currently supports SAV (depth <= 0.9 m). Coverage data from our annual SAV monitoring was then converted to DW and interpolated within these areas to estimate areal biomass coverage ($g\ m^{-2}$). DW and elemental content was then summarized within three ecozones within the river: oligohaline-lacustrine (OL), freshwater-lacustrine (FL), and freshwater-riverine (FR).

Results and Discussion

Patterns in mean annual biomass, expressed as metric tons DW, showed distinctly different patterns among the three ecozones. In the OL section SAV biomass was 2 to 75-fold greater than phytoplankton biomass and increased study while phytoplankton biomass decreased through the period. The disparity was lower in the FL section. SAV biomass was 10 to 26-fold greater than phytoplankton biomass. SAV biomass increased nominally and phytoplankton biomass decreased through the period. Biomass differences were less pronounced in the FR section. There was only a 0.3 to 6-fold difference. No temporal patterns were evident through the period.

As expected, total N and P closely followed biomass patterns. Mean annual total P content was 2 to 60-fold, 8 to 29-fold, and 0.3 to 5-fold greater in SAV in the OL, FL, and FR zones, respectively. Mean annual total N content was 1 to 34-fold, 5 to 16-fold, and 0.2 to 3-fold greater in SAV in the OL, FL, and FR zones, respectively. These results show that over an annual cycle SAV is a far larger potential nutrient sink than phytoplankton. These data also suggest that as restoration measures progress and water quality conditions improve SAV will likely expand and serve as an even larger nutrient sink, in a positive feedback-type cycle.

Another important feature regarding nutrient contents of SAV and phytoplankton is the recycling rate. Phytoplankton grow much more rapidly (i.e., bloom) than SAV and take up large amount of nutrients. But those blooms also senesce and die precipitously causing large releases of inorganic and labile nutrients. This bloom/crash cycle causes nutrients to be quickly recycled and perpetuates the cycle. These cycles also tend to decrease the production/respiration ratios in the system. Conversely, SAV grows and turns over more slowly. Sequestering nutrients for a longer period slows nutrient cycling and tends to raise p/r ratios. However, recycling rate considerations are overwhelmed by the level of nutrient loading. The standing stock of phytoplankton and SAV represent only 0.02-0.047% and 0.02-3.35% of the N load and 0.01-0.37% and 0.01-3.10% of the P load, respectively. Thus, it is clear that both phytoplankton and SAV are minor pools within the nutrient budget of the LSJRB.

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FACTORS AFFECTING THE MAXIMUM DEPTH OF COLONIZATION BY SUBMERSED MACROPHYTES IN FLORIDA LAKES

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In the 1990s, the Florida Legislature directed the state's water management districts to establish minimum water levels for lakes (Section 373.042, Florida Statutes). The Southwest Florida Water Management District (SWFWMD) developed methods for establishing minimum lake levels (Chapter 40D-8. Florida Administrative Code), which included use of the model developed by Canfield et al. (1985) to assess potential changes in the coverage of submersed vegetation with changes in water transparency. The Southwest Florida Water Management District, however, recognized the need to develop a more robust model from a larger number of lakes.

This study was designed based on the earlier work of Canfield et al. (1985) in an attempt to develop more robust model/models for use by SWFWMD. The first part of the study involved the sampling of 32 Florida lakes. At each lake, Secchi disk (SD) transparency, light attenuation coefficient values, plant and sediment type, and slope were examined with respect to the maximum depth of plant colonization (MDC). Additionally, SD transparency, color, chlorophyll, and water column nutrients (total phosphorus and total nitrogen) were examined with respect to the maximum depth of macrophyte growth for 279 lake-years of information.

In the 32 lake study, MDC was shown to be significantly related to light through measurements taken by a SD (r^2=0.46) and a light meter (r^2=0.41). Plant and sediment type were not shown to exert a significant ($p>0.05$) influence on the depth of aquatic plant colonization. Lake bottom slope was not shown to be significantly correlated (r^2=0.03) to the maximum depth of plant growth.

For the 279 lake-year study, the maximum depth of aquatic plant growth was significantly related to SD transparency (r^2=0.67), color (r^2=0.41), chlorophyll (r^2=0.30), total phosphorus (r^2=0.42), and total nitrogen (r^2=0.33). An upper limit line relating MDC to SD in meters was calculated and was found to be equal to: $\log_{10}$ (max MDC) = 0.52 $\log_{10}$ (SD) + 0.59. The maximum MDC line represents where light is the limiting environmental factor. When MDC values falls below the line, there is some other limiting environmental factor inhibiting plant growth other than solely light.

This study has confirmed the earlier findings of Canfield et al. (1985) that the maximum depth of macrophyte colonization can be predicted using SD transparency. Also, the maximum depth of plant growth can be predicted reasonably well by light meter readings. The other water chemistry parameters examined (color, chlorophyll, total phosphorus, and total nitrogen), were found to provide estimates for predicting the potential extent of macrophyte growth and could be useful to managers when lake transparency readings are unknown.

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NOTES

SESSION 11

POTPOURRI – GOOD STUFF!!

DEVELOPMENT OF PERFORMANCE MEASURES TO EVALUATE ALTERNATIVE STRUCTURE OPERATING CRITERIA IN THE KISSIMMEE BASIN

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The South Florida Water Management District (SFWMD) manages water levels in 19 interconnected water bodies in the Kissimmee Upper Basin and flow within the Kissimmee River in the Lower Kissimmee Basin through the operation of 13 water control structures. In the greater than 25 years since the last comprehensive revision of the operating rules, management of this spatially-complex system has been complicated further by several emerging issues including increased nesting by the endangered snail kite, the development of Fluridone resistant hydrilla, rapid population growth, and the demands of the federally-authorized Kissimmee River Restoration Project (KRRP). To address these issues, SFWMD is conducting the Kissimmee Basin Hydrologic Assessment, Modeling, and Operations Planning Study. The goal of this study is to identify alternative structure operating criteria to meet interim and long-term flood control, water supply, aquatic plant management, and natural resources water management objectives while also achieving the ecological integrity goal of the KRRP, preserving and/or enhancing the ecological values of the Kissimmee Chain of Lakes and balancing impacts to Lake Okeechobee.

The diverse and competing water management objectives of the Kissimmee Basin are being represented by a comprehensive set of evaluation performance measures being developed collaboratively from input by an interagency team of professionals from SFWMD, U.S. Army Corps of Engineers, U.S. Fish & Wildlife Service, U.S. Environmental Protection Agency, Florida Fish & Wildlife Conservation Commission, Florida Department of Environmental Protection, Florida Department of Agriculture & Consumer Services, local governments, and stakeholders. Performance measures are quantitative indicators of how well (or poorly) a specific objective is being met. For this study, conceptual understandings of how ecology and hydrology of the basin interact form the basis of the performance measures. The most important aspects of hydrology were distilled into hydrology-based evaluation performance measures by examining historic hydrologic data and by leveraging the knowledge and understanding of similar systems from subject matter experts. Metric ranges attempt to define the desirable hydrologic conditions that will achieve the goals of the study.

Evaluation performance measures characterize lake stages by assessing peak values, seasonality, variability, fluctuation, and recession rates. The performance measures also address water supply availability for consumptive use, hydrilla management, KRRP restoration goals, and flows to Lake Okeechobee. The set of performance measures will be used to evaluate alternative operational plans using output from a screening-level water budget model and a hydrologic and hydraulic model (MIKE 11/MIKE SHE).

Evaluation performance measures are critical components of the Kissimmee Basin Hydrologic Assessment, Modeling, and Operations Planning Study that will be used to identify alternative structure operating criteria to meet the diverse water management objectives of the Kissimmee Basin. Refinement and consolidation of the evaluation performance measures will continue during the alternative plan formulation and evaluation phases of the study.

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NOTES

WIND AND WATER LEVELS IN KISSIMMEE BASIN LAKES DURING THE 2004 HURRICANE SEASON

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The 2004 hurricane season was unprecedented with four hurricanes making landfall in Florida and three passing over the Kissimmee Basin in central Florida. The South Florida Water Management District manages water levels in 19 water bodies within the basin. Anecdotal information suggests that wind associated with these storms created waves that reduced water clarity by suspending sediments and that reduced the quantity of submerged aquatic vegetation (primarily *Hydrilla verticillata*) by uprooting and depositing it along the shoreline. The effect of wind-driven movement of water associated with these storms was quantified by wind setup (difference between water levels at the up-wind and down-wind ends of a lake). Before reaching the Kissimmee Basin, these storms had decreased in intensity to tropical storms. The passage of each was marked by decreases in air pressure to <745 mm Hg and increases in wind speed to maximum values between 40 mph and 50 mph. During Charlie, wind setup on Lake Kissimmee approached a difference of 6 feet between stations located near the northern and southern ends of the lake. This movement of water set in motion a surface seiche that rapidly dampened. Frances approached Lake Kissimmee from the opposite side and at a more oblique angle. Consequently, the movement of water in the lake was in the opposite direction and involved a smaller difference of only 1.8 feet. Analyses from other lakes in the basin suggest that characteristics of storms and lakes (e.g., length) can help explain differences in impacts among lakes.

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SESSION 12

EMERGING TECHNOLOGIES

RECENT AND COMING ADVANCES IN EUREKA WATER QUALITY INSTRUMENTATION

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Eureka Environmental attempts to provide water quality monitoring equipment with improved performance and increased ease of use. Our dissolved oxygen membrane cap makes it easier to change the DO membrane, and results in more consistent data. The incorporation of a commercial PDA into our field display unit significantly lowers the cost compared to custom-built displays, while adding features such as extra memory, color display, Microsoft Word and Excel, GPS capabilities, integration of notes and even voice recordings to data files, and the ability to operate with other brands of multiprobes. The Manta (Eureka's multiprobe) plugs directly into any PC USB port via an adapter cable, and does not require external power for operation. The instrument was designed to allow easy software upgrades by the user, for access to new features as they are developed without loosing calibration. To minimize crosstalk, electronic noise, and measurement errors, our electronics for each sensor have been designed to be completely isolated, incorporate a water ground, and utilize ratiometric measurements to account for any variations in batteries or power supply voltages.

Eureka's free-flowing conductivity electrode design allows rapid sample equilibration. Our flat glass pH electrode is more rugged and easily cleaned, and uses a refillable large-volume reference electrode with a clear housing that lowers operational cost, increases accuracy, and extends deployment time. The DO circulator was designed for directional flow, to maintain accurate DO readings even in stagnant water. A highly accurate level sensor (±0.005 ft) was developed to maintain its stated accuracy for over 1 year. Our multiprobe cables contain a self-sealing water block, are available in custom lengths, and are easily replaced by the user. The multiprobe's clear housing and diagnostic LEDs allow easy trouble shooting in the field. Calibration logs and Sensor Response Factors allow the user to track the performance of their sensor and determine in advance when replacement may be necessary. Where possible, sensors have been designed to be short and recessed into the end cap, to minimize the amount of expensive solutions needed for calibration.

New Products Being Released

Eureka has partnered with Insite IG to provide an optical DO sensor with years of tested field use in the wastewater treatment field. Rather than use the more common lifetime measurement (smaller signals, more complicated electronics), Insite has perfected a stable steady-state measurement technique that has allowed some of their customers to operate 2 years between calibrations. The sensor does not require stirring, membranes, electrolyte, or any other replacement parts. We now offer a telemetry system that uses satellite, radio, or Ethernet connections to accomplish bi-directional communication with the multiprobes, storing the data on a secure web site easily accessible to the user. The system also offers the setting of alarms and paging or email notification of user-specified events.

Eureka is also incorporating Turner's chlorophyll and rhodamine (for tracer dye studies) sensors into our line of multiprobes. For customers who require added accuracy in temperature measurements, we can perform custom characterizations of our temperature probes to deliver ±0.05 °C accuracy. The development of a Total Dissolved Gas (TDG) sensor is nearing completion, and contains pre-calibrated electronics for increased accuracy and stability. We have also developed a temperature and dissolved oxygen logger, and are designing a line of 2-3 parameters instruments that cost less but incorporate sensors with the accuracy and reliability of higher-end instruments.

Other Multiprobe Advances Under Development

Eureka is exploring advances in torroidal, electrode-less conductivity sensors that allow them to be used in fresh waters; these sensors are less susceptible to fouling and are more immune to electrical interference. We are exploring the use of a synchronized barometric pressure sensor, to make automatic BP corrections to DO percent saturation readings and allow precise level measurements to be made without the need for the traditional vented cables. A new line of instruments is under development that utilizes a modular sensor design, where the sensor incorporates its own electronics; this allows a sensor to retain its own calibration, and results in a "plug and play" system where sensors can be swapped or added by the user without sending the instrument back to the factory. Wireless data download and instrument control will also reduce the need for cables.

NOTES

ID&D® (INTEGRATED DREDGING & DEWATERING) INTEGRATED SYSTEMS FOR THE LOCATION, CHARACTERIZATION, REMOVAL AND DEWATERING OF LAKE SEDIMENTS

(Continued from Session 2)

Glenn Green
J.F. Brennan Co., Inc. – La Crosse, Wisconsin

Jim Hibbard
Hibbard Inshore, LLC - Lake Angelus, Michigan

During the last 15 years, there have been significant advances in the technologies, systems and equipment used to precisely locate, characterize, remove, segregate, dewater and beneficially reuse dredged sediments.

Purpose, Scope and Objectives

To educate and familiarize the audience with proven technologies, systems and equipment that are being used to locate, characterize, remove, segregate, dewater and beneficially reuse sediments from waterways. This paper will detail 4 proven **ID&D®** systems that Brennan has successfully implemented on projects throughout the United States including two projects in Palm Beach County.

Methods or Approach

a. **Location, Characterization and Modeling of Sediments:** Brennan has worked with Hibbard Inshore to develop accurate systems that identify, locate and model in-situ sediments. This data is translated into Brennan's Hypack®/Dredgepack® dredge guidance systems.

b. **ID&D® Integrated Dredging & Dewatering Systems:** Brennan has a fleet of 6 hydraulic, swinging ladder, cutterhead dredges that are driven by our Hypack®/Dredgepack® systems with position accuracy from our RTK/GPS positioning systems. These dredges can be integrated with any of Brennan's four (4) separate systems to segregate and dewater the sediments.

c. **Beneficial Reuse of Dredged Materials:** In order to beneficially reuse sediments that are dredged from waterways, the sediments must be sufficiently segregated and dewatered. These sediments are then readily transportable and if necessary recombined in their dewatered state and then transported to their final destination.

Findings and Results

C-51 Canal: Brennan is currently using subbottom profiling and modeling from Hibbard Inshore, to guide our dredges on the C-51 Canal in Palm Beach County. The dredges are pumping muck materials to Brennan's ID&D® dewatering system.

Lake Osborne: Lake Osborne, West Palm Beach, Florida is one of the key case histories for the use of the "ID&D®" – Integrated Dredging and Dewatering System. All of the dredged material was quickly and cost-effectively available for beneficial reuse.

Conclusions and Recommendations

With the wide variations of sediments in the waterways in Florida combined with limited space available for deposition and dewatering of dredged material, users of these technologies will be able to incorporate and apply these technologies to your dredging projects.

When properly applied, hydraulic transport is the most efficient and cost effective method to move and place solids. Beneficial reuse of dredged material as well as limited containment areas can now be addressed using our ID&D® System – Integrated Dredging & Dewatering. Brennan has the methods, experience and equipment to adapt to your size and complexity of the project.

Benefits

- Accurate location, characterization of in-situ sediments
- Detailed sub-bottom modeling for dredge cuts
- Earlier project completion
- Minimal public and environmental disturbance
- Continuous process
- No need for extensive settling basins
- Eliminates long pipelines and boosters
- Processes a variety of materials
- Highly automated
- Low turbidity of return water
- Environmentally sensitive – equipment, systems, process chemicals
- Dewatered material is stackable and immediately available for beneficial use
- Streamlines agency permitting

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