Pros and Cons of Issues Identified by Stakeholders Regarding the Future Management of Walton County's Coastal Dune Lakes

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Choctawhatchee Basin Alliance, under guidance from the
Walton County Coastal Dune Lakes Advisory Board

Report by:

Mark V. Hoyer and Daniel E. Canfield, Jr.
Florida LAKEWATCH
Department of Fisheries and Aquatic Sciences
University of Florida/Institute of Food and Agricultural Sciences
Gainesville, FL

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Background

Walton County contains many ecological treasures, which attract visitors from all over the world, creating one of the fastest growing (i.e., population) counties in the nation (Figure 1). In 2002, the Walton County Dune Lakes Advisory Board identified 18 named coastal dune lakes in south Walton County along 26 miles of Florida coastline (Table 1). There may be other lakes that could be considered coastal dune lakes. For example, Little Deer Lake (not a recognized dune lake) drains into Deer Lake (a recognized dune lake) like Fuller drains into Morris (both of these are recognized dune lakes). Therefore, Little Deer Lake should probably be classified as a coastal dune lake. These coastal dune lakes are extremely rare. In Florida, they are found only in the Florida Panhandle. Around the world, coastal dune lakes also exist in Australia, Madagascar, New Zealand, the northwest Pacific Coast of the United States and South Carolina.

Coastal dune lakes are generally found within two miles of the coast and are typically shallow and irregularly shaped. The lake-water is composed of both fresh and saltwater obtained from tributaries, groundwater seepage (in both directions, from uplands to the lakes and from the Gulf to the lakes), rainfall, and coastal storm surges. Most dune lakes around the world are called freshwater lakes with varying periods of saltwater intrusion. The lake-water is generally colored (e.g., tea or black colored) due to watershed contributions of dissolved organic matter. While these lakes are exposed to normal weather conditions just like any lake, Florida coastal dune lakes are also tremendously impacted by hurricane activity (i.e., storm frequency, strength, and duration).

The coastal dune lakes of Walton County are scientifically interesting because of their intermittent connection to the Gulf of Mexico. This periodic connection serves as control for flood-level waters (relative to structures and associated infrastructure) by opening a conduit to the Gulf. When a lake reaches a critical pre-flood level, breaching water forms an outlet (channel) through the dune system and empties the lake water into the Gulf. Depending on tides and weather conditions, saltwater and saltwater biota from the Gulf may fill the lake and any biota voids created by the lowered water level. The drainage of the lake and potential exchange with the Gulf continues until equilibrium is reached and the opening closes. When there is an exchange with the Gulf of Mexico, a brackish water-body is formed. Depending on the exchange, an estuarine ecosystem may be created. Each of Walton County's coastal dune lakes, however, has individual outlet characteristics, with outlet openings varying in length, frequency and duration. These openings occur based on each lake's critical water level, which is driven by climatic conditions (e.g., droughts and rain). As a result, some of the dune lakes can be completely freshwater, some brackish, and some salty, with varying degrees of salinity occurring between different lake stages. The changing condition of water chemistry in the coastal dune lakes makes them dynamic, biologically diverse ecosystems.

Walton County's tremendous population growth (Figure 1), especially in the vicinity of the coastal dune lakes, has raised concern among citizens over the "health" of these exceptional systems. For this reason, the Walton County Board of County Commissioners extended provisions in the Walton County Land Development Code and Walton County Comprehensive Plan for the protection of the dune lakes. Additionally, the County Commission established (Ordinance 2002-02: Appendix I) the Coastal Dune Lakes Advisory Board (CDLAB) in 2002 (CDLAB Manual: Appendix II). The mission statement for this advisory board is as follows: "To serve, protect and perpetuate the Coastal Dune Lakes of Walton County through mitigation of the effects of development." The CDLAB has multiple objectives, which fall under three major headings: 1) Action, 2) Education, and 3) Perpetual Protection. One objective that falls under the Action heading is development of an action plan (essentially a lake management plan) for each lake. This report is Phase II of the TEAM approach (described later in this section), which shall contribute to the development of comprehensive coastal dune lakes management plans by the CDLAB. Walton County citizens who live around the lakes, utilize the lakes and/or are just concerned about the future for these lakes, identified major issues of concern for each of the coastal dune lakes and the issues identified are addressed in detail in this report.

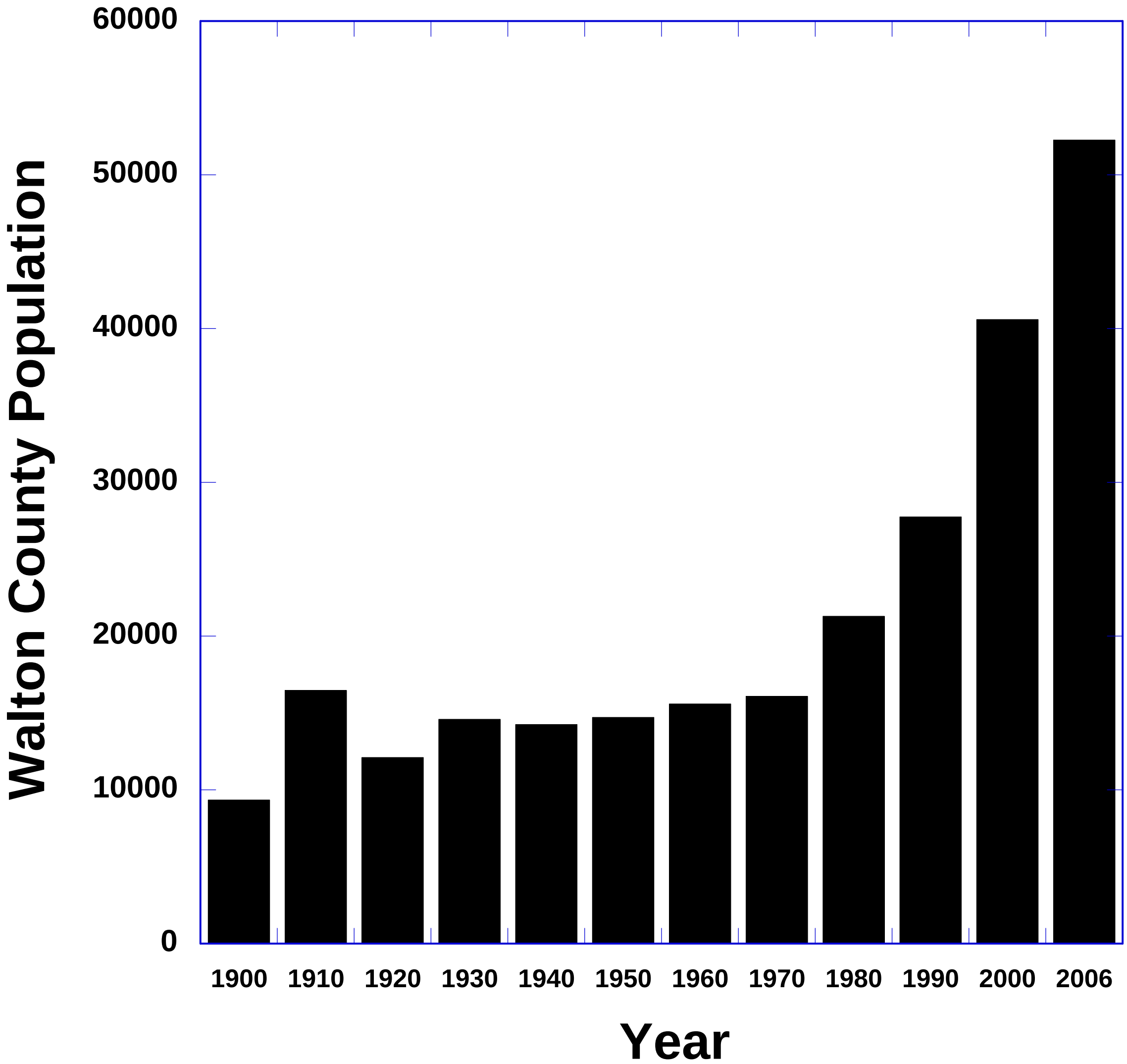


Figure 1. Population growth statistics from the U.S. Census Bureau for Walton County, Florida.

Table 1. List of Walton County's coastal dune lakes identified by the Walton County Dune Lakes Advisory Board (CDLAB Manual 2002: Appendix II). Lakes are listed from west to east based on their location in Walton County. Choctawhatchee Basin Alliance (CBA) and Florida LAKEWATCH volunteers collect water chemistry data on all but Stewart, Horseshoe, Tresca and Little Deer.

County	Lake	CBA/LAKEWATCH Data Available
Walton	Stewart	Yes
Walton	Horseshoe	No
Walton	Fuller	Yes
Walton	Morris	Yes
Walton	Campbell	Yes
Walton	Stallworth	Yes
Walton	Allen	Yes
Walton	Oyster	Yes
Walton	Draper	Yes
Walton	Big Red Fish	Yes
Walton	Little Red Fish	Yes
Walton	Alligator	Yes
Walton	Grayton (Western lobe of Western Lake)	Yes
Walton	Western	Yes
Walton	Western Northeast (Eastern lobe of Western lake)	Yes
Walton	Eastern	Yes
Walton	Eastern North (Section of Eastern Lake north of CR 30A)	Yes
Walton	Tresca Lake	No
Walton	Little Deer[1]	No
Walton	Deer	Yes
Walton	Camp Creek	Yes
Bay/Walton	Powell	Yes

[1] Not yet recognized as a coastal dune lake.

Throughout 2006, Mr. Phillip Ellis with the Choctawhatchee Basin Alliance (CBA) and Mr. Scott Jackson with the University of Florida-IFAS Extension Service (UF-IFAS), under the guidance of the Coastal Dune Lakes Advisory Board (CDLAB), hosted a series of community meetings to initiate the development of management plans for the coastal dune lakes of Walton County. Their efforts were the first step in an approach called "The TEAM Approach" which was to be used to develop a generalized Walton County Dune Lakes Management Plan. TEAM stands for "Together for Environmental Assessment and Management" and was developed at UF-IFAS to assist communities with the development (in a reasonable amount of time) of workable (acceptable to the majority of citizens), comprehensive (dealing with the most critical issues identified by participants) lake management plans and water resource policy (Canfield and Canfield 1994).

TEAM is a three-step process. It involves "stakeholders," lay citizens, and technical "experts." Stakeholders are individuals or groups directly affected either by a lack of action or by one or more courses of action which could be chosen to address a lake management issue. Examples of stakeholders include lakefront property owners (homeowners or businesses), interest groups such as the South Walton Community Council, Eastern Lake Neighborhood Association, and Lake Powell Community Alliance, as well as agency personnel at the policy making level. In Phase I, these people (especially the stakeholders and everyday citizens) identify, define, and prioritize their concerns and potential courses of action concerning water resource issues (Appendix III). Next, "pro" and "con" information is developed for each issue using the best available science (this report). Once assembled, this information is provided to everyone who was involved at the first meeting and other interested parties if requested. They come together to discuss and ultimately vote on a course of action with regard to a lake management plan or water resource policy.

The TEAM process was developed because, as Robert T. Lackey of the U.S. Environmental Protection Agency wrote in 2006, "many current ecological policy problems are contentious and socially wrenching". Lackey (2006; see Appendix IV) also noted that there are several generalizations—which he called Axioms of Ecological Policy —that apply to today's ecological policy problems. They are: (1) the policy and political dynamic is a zero-sum game; (2) the distribution of benefits and costs is more important than the ratio of total benefits to total costs; (3) the most politically viable policy choice spreads the benefits to a broad majority with the costs limited to a narrow minority of the population; (4) potential losers are usually more assertive and vocal than potential winners are and, therefore, disproportionately important in decision making; (5) many advocates will cloak their arguments as science to mask their personal policy preferences; (6) even with complete and accurate scientific information, most policy issues remain divisive; (7) demonizing policy advocates who support competing policy options is often more effective than presenting rigorous analytical arguments; (8) if something can be measured accurately and with confidence, it is probably not particularly relevant in decision making; and (9) the meaning of words matters greatly, and arguments over their precise meaning are often surrogates for debates over values. Certainly, many of the problems identified by the citizens of Walton County for the dune lakes are associated with one or more of Lackey's (2006) axioms. However, recognizing the importance of Lackey's axioms in Walton County still requires recognition of H. A. Simon's pivotal observation in 1955, "Significant changes in human behavior can only be brought about rapidly if the persons who are expected to change participate in deciding what the change shall be and how it shall be made."

Unfortunately, after Phillip and Scott hosted Phase I of the TEAM process in 2006, they each began to pursue other career opportunities and the development of the Coastal Dune Lakes Management Plan stalled. Therefore, Ms. Julie Terrell, Director of CBA, requested that Florida LAKEWATCH finish developing the TEAM management plan for Walton County's coastal dune lakes. She selected Florida LAKEWATCH because LAKEWATCH has successfully used the TEAM approach to develop lake management plans for several Florida lakes, including the Tsala Apopka Chain of Lakes in Citrus County, Lake Wailes in Polk County and the Forest Hills Lakes in Hillsborough County.

In January 2008, Florida LAKEWATCH prepared a report summarizing the issues identified in the 2006 Phase I effort (Hoyer and Canfield 2008; Appendix III). The report was then presented to the original participants of Phase I, including the CDLAB members and county personnel, as well as interested lay citizens. After giving both groups time to read the report, Florida LAKEWATCH personnel held meetings with both groups to finalize all issues of concern and fielded multiple phone calls and emails from individuals not able to attend these meetings. The following is a final list of seven major issue titles listed in order of importance as identified by participants:

1) Who is in Charge?
2) Outlet Management
3) Water Quality
4) Watershed/Inlet Management
5) Aquatic Plant Management
6) Education
7) Fish and Wildlife

Introduction

LAKE MANAGEMENT is part science and part politics. Individuals called "professionals" are generally thought to be the ones who practice science. Science in some form, however, is also practiced everyday by the everyday citizen. Many individuals tend to believe only elected officials practice politics. But politics are also practiced by virtually everyone. Science and politics are prevalent in virtually every form of human interaction, and they are how the compromises of life are reached. For many individuals, however, the scientific and political processes are considered to be very different. There are indeed many differences, but there is one commonality -- people!

The importance of people in lake management rests on the singular fact that all people, regardless of whether they are directly involved in the scientific or political processes, have opinions. When beginning the formulation of a lake management plan, all opinions must be considered valid. Over time, as facts become better known, opinions will most likely change. The importance level of individual problems may also change over time, depending on the social, economic and political attitudes of the day. Consequently, any lake management plan must be considered a "living document," just like the Constitution of the United States.

Stakeholders identified seven major issues of concern listed above regarding the management of Walton County's coastal dune lakes. LAKEWATCH and CBA subsequently gathered all available data regarding individual issues. Then we consulted scientists and other professionals with direct knowledge of the major issues advanced to discuss the facts as best known.

This document--that you are reading--represents a compilation of available information. We may have unintentionally missed some important information. However, we also recognize that there is already a tremendous amount of reading material. **Please do not be discouraged or frightened by the amount of material.** You have been given a summary of the available information related to each issue of concern. Following this information, some viable options for the management of Walton County's coastal dune lakes are presented. In mid-summer, you will have the opportunity to meet with your fellow citizens to discuss the options and advance your ideas about how to manage these lakes.

Please remember that science cannot always provide absolute answers in a given time, especially considering the large natural variability of most ecological processes involved with lake management. Sometimes scientific answers even take centuries to evolve. Given this uncertainty, you will be trying to adopt the best available approaches known at this time. This does not mean that there will not be opposing views regarding the chosen approach. Your job will be to find out where the compromises exist and which are acceptable.

When there are opposing views as to the approach that should be taken, please remember that these concerns can be monitored into the future to determine if they are correct. Lakes are very resilient and corrections in the management plan can be made in the future if need be! Even at this time, there are scientific studies underway to provide better information on certain issues. Do not allow yourself to become trapped in the "Do Nothing" option for fear that you do not have enough information to manage your lake. You will never have all of the information. There are, of course, times when doing nothing is an acceptable choice. However, it is generally best to consider different views as hypotheses that can be tested in the future. The management plan can be changed at a later date based on new information, if deemed appropriate. This allows all opinions to remain valid until the community is convinced by facts of evidence that certain opinions or concerns are no longer valid. Again, it is extremely important to remember that a lake management plan is a "living document," which is persistently subject to review and change as agreed upon by you, the citizens who adopt it.

Issue 1: Who is in Charge?

When controversies arise regarding the management of lakes, and citizens become intimately involved in the issues, the most frequently asked question is: "Who is in charge here?" This question gets asked because there are a myriad of federal, state, and local public agencies that have statutory responsibilities in the arena of lake management. To the everyday citizen, the interaction among agencies seems to be similar to a giant bowl of spaghetti. There seems to be no beginning and no end, and there certainly seems to be no timely answer to their questions. More importantly, when there is not a money issue, everyone is willing to say his or her agency is in charge, but when settlement of the issue might require the expenditure of money, the most frequent response heard is "***Not Us***!"

The agencies are doing nothing wrong, and they do not have a lack of caring. Committed public employees (who are fellow citizens) staff the agencies, but the agencies are also following statutory requirements. Unfortunately, the bureaucracy can lead to intense citizen frustration. Consequently, it is very important for the involved citizen to understand history as it relates to lake management. The answer to the question of who is in charge is directly linked to the history of the United States, so let's review some history.

Who is in charge here and how did they get in charge? Water played the dominant role in the settlement of the western United States and Florida. Water was a liquid highway for transporting people and goods. At the federal level, involvement in water resource management essentially began with the U.S. Army Corps of Engineers. In the mid-1820s, the U.S. Army Corps of Engineers, under the guise of improving national defense, began digging canals and deepening river channels. While these efforts were important to national defense, they were also the keys to economic development. By the 1890s, the Corps had assumed additional responsibilities, including the control of aquatic plants (primarily water hyacinth) in the waters of the Southeast. Since then, water development projects have been a dominant feature in U.S. domestic policy, and the Corps oversees many of these projects. As a result of these efforts and passage of federal statutes such as the National Environmental Policy Act and the Fish and Wildlife Coordination Act, the Corps has been given immense regulatory responsibilities.

In the late 19th century, the Conservation Movement was born. The federal government in 1871 created the U.S. Fish Commission, a forerunner of the U.S. Department of Interior' s Fish and Wildlife Service. The Commission was originally created for the purpose of investigating the decline in commercial fisheries. After a short time, the Commission was charged with the task of raising fish and distributing them throughout the United States for the promotion of commercial fisheries. While conservation was a concern, economic development and sustainability were also very important. With the rise of the U.S. Fish and Wildlife Service, considerable research was done on fish and wildlife. Ideas on how to manage these animal populations emerged, and the States began to create their own fish and wildlife agencies. This allowed the U.S. Fish and Wildlife Service to transition into a more regulatory role.

By the 1960s, concern for the environment began to emerge as a political concern. Numerous federal statutes were created, including the Endangered Species Act, the Clean Water Act, the National Environmental Policy Act, and the Fish and Wildlife Coordination Act. The U.S. Environmental Protection Agency was also formed in the 1970s. All these actions brought greater protection to the environment, but also brought more rules and regulations at the federal level. The States to a large degree have to abide by these rules and regulations too, and nearly all lake management programs require some type of federal permit or oversight.

At the state level, economic development was the primary concern in the 19th and early 20th centuries. For example, Florida's government prior to 1850 sought to encourage settlement by offering land to anyone who would establish a homestead and defend it for five years. Transportation, however, was the great problem of early farmers, and how to get their products to market became a major concern for many of Florida's communities. Florida responded by creating the Board of Trustees of the Florida Internal Improvement Fund. The Board of Trustees implemented programs to create canals and drain wetlands, including lands around lakes. They also helped sell the drained lands. It is important to remember that Florida was an extremely poor state at that time and economic development was needed for the betterment of all Floridians.

By the early 20th century, states like Florida began establishing their own fisheries and wildlife agencies for the purpose of research, management, and regulating the take of fish and wildlife. (States Rights is a paramount political concern.) Regulations by agencies such as the Florida Fish and Wildlife Conservation Commission (formerly the Florida Game and Fresh Water Fish Commission) increased dramatically. Regulations of fish-catching methods, however, were usually politically motivated and designed to restrict the effectiveness of some people while enhancing that of others. Therefore, political involvement caused many state fish and wildlife agencies to become constitutional agencies.

Despite increased regulatory power and federal funding, state fish and wildlife agencies continued to be embroiled in political controversies that affected the economic well being of many people. One of the most controversial issues involved the take of fish by commercial fishermen and recreational anglers. Over time, commercial fishermen in states like Florida were largely displaced from the freshwater lakes by recreational anglers. Society had determined that fish in lakes were more valuable to the developing recreational interests. This change by itself might not have seemed important to many individuals, but it began to affect the common property principal. States as the public trustees of fish and wildlife could now allocate resources to specific groups.

Concern about the environment influenced federal law after the 1960s, and the States too responded with new laws and agencies. For example, Florida with its increased economic wealth developed many environmental regulation organizations. These included the Department of Natural Resources and the Department of Environmental Regulation (both agencies are now the Florida Department of Environmental Protection). Florida further created five water management districts, including the Northwest Florida Water Management District. Local governments that had sufficient economic resources also created environmental departments (sometimes embedded storm water or planning departments due to larger issues) with their own regulations. Given these developments and the passage of so many new environmental laws with their associated rules and regulations, many individuals thought environmental issues would go away. Unfortunately, this has not been the case because there are many conflicts yet to be resolved!

Many natural resource managers and members of the public believe the law is the law and it remains static unless a new law is passed. They also believe the many rules and regulations passed by agencies are also static law. Agencies, therefore, are considered to be the enforcers of “clear” rules. Thus, any legal problem would be seen as cut and dried, but this is seldom the case (just ask any lawyer).

The police power of the federal and state governments means that they can abridge the rights of private property owners in order to protect natural resources, but only under certain circumstances. The government of Florida takes the seriousness of abridging the rights of any individual very seriously (e.g., the Burt Harris Private Property Law) as does the entire U.S. judicial system. Consequently, the law is not a set of static principles. It is dynamic and sets the rules as guidelines for resolving conflicts. The courts provide a formal remedy only when conflicts cannot be resolved outside the judicial system.

It is the conflict-resolution processes that most natural resource managers and everyday citizens find most uncomfortable. When serious situations arise, the conflict-resolution process is generally passed to lawyers. The lawyers recognize that the law is dynamic and arguments can be made within the judicial system to favorably interpret the law. However, most lawyers will try to negotiate a settlement outside of the courts.

There are many ways in which law impacts lake management. Four of the most important, as described by Berton Lamb and Beth Coughlan in their 1993 article "Legal Considerations in Inland Fisheries Management," are: (1) prescribing rules of conflict, (2) balancing the powers of government branches, (3) defining the powers of central [federal] government, and (4) describing the boundary between legal and political issues. For many public employees and concerned citizens, they will not end up in court when conflicts arise. They will participate in negotiations and enforcement actions outside the courtroom. The law does more than just guide conflict into the judicial system. It helps set the behavior of agencies, their missions, and their powers, while also constraining their actions.

The law also balances power between the legislative and executive branches of government. These two branches of government have a dynamic equilibrium designed to work itself out over time, and the branch with the most power at any given time may be hard to determine until court action takes place. The third major impact of law defines the power given to the central government versus the states. Here the Constitution defines basic government powers, but again there is always the struggle between the states and the federal government. The fourth major impact is deciding what is a legal question and what is political. In the United States, everything is open to debate, but some things are regarded to be beyond partisan politics. For example, there is no longer any serious debate that fish and wildlife populations are largely under the control of state governments.

There are some important legal doctrines that need to be considered when developing a lake management plan. One of these doctrines is the Riparian Doctrine. This doctrine simply states that persons owning land that abuts a body of water have the right to use the water. Persons whose land does not abut the body of water have no right and typically must rely on groundwater. During times of scarcity, however, there must be reasonable use. Another important doctrine is the Public Trust Doctrine. The government has trust responsibilities for the management of natural resources. In some jurisdictions, these responsibilities include the protection of fish and wildlife habitat, access, and aesthetic characteristics. Failure to consider the Public Trust Doctrine may result in the court reversing a management decision even years after the decision was made.

Another important doctrine is “The Taking of Private Property.” The Constitution of the United States provides that the government without just compensation under due process of law cannot take private property. Property rights stand for a host of legal doctrines and policies that essentially tell landowners what they can or cannot do with their property. In as much as legislation protecting wetlands, rivers, and other environmental values are becoming commonplace, the principal of private property rights remains in a state of flux.

A final concern for individuals trying to develop a lake management plan is an understanding of politics. In the 1990s and perhaps even today, politics is often viewed in an unfavorable light.

Politics, however, is an honorable pursuit. It is often remarked, "Politics is the art of the possible." Learning what can be done and how to accomplish management goals is a key to the political art. Working with elected leaders is perhaps one of the most important things concerned citizens can do!

One of the first tasks for the concerned citizen is becoming involved in the process of selecting good leaders. This means becoming involved in electoral politics. Once a person is elected to office, they still need the help of concerned citizens and natural resource managers. It is extremely important to work with legislators to help them understand the issues. It is also extremely important to remember that the implementation of politics requires a unique skill. The political arena deals with the process of working out how statutes will be administered by the executive branch. After a law is passed (even what appears to be a clearly stated law), there still may be considerable interagency bargaining to implement the law. The bottom line is that the establishment of a lake management plan does not end citizen involvement. Concerned citizens must remain actively involved and always remember a lake management plan is a "living doctrine." You must also contemplate that sometimes you and your perceived opponents have to agree to disagree.

If citizens are to remain involved, they should always remember the words of U.S. House of Representatives Speaker Thomas “Tip” O’Neill who was fond of saying: “All Politics are Local.” What this means for citizens concerned about Walton County’s coastal dune lakes is that the first governmental organization to engage is the Walton County Board of County Commissioners. Fortunately, the Board of County Commissioners, in passing Ordinance 2002-02 in 2002 (Appendix I), has already empowered the citizenry of Walton County by establishing a permanent Coastal Dune Lakes Advisory Board. The Board of County Commissioners appoints this seven (7) member advisory board. The advisory board may have as many as ten (10) non-voting ex officio members representing recognized citizens groups, consultants under contract with the County and/or outside environmental agencies. The advisory board shall monitor the coastal dune lakes and activities that effect the environmental conservation of the lakes that occur within the lake, in areas within the coastal dune lake protection zone and within the watersheds of the coastal dune lakes. At monthly meetings, the advisory board can hear and provide diverse citizen input on issues related to the lakes and has a relatively direct channel to the Board of County Commissioners by reporting to the county's Growth Management Director.

Summary of Potential Management Options for Issue 1: Who is in Charge?

Option 1: The "Do Nothing" Option.

Justification:

There are times when the "*Do Nothing" Option* is the most viable and positive action that can be taken, and given the proactive leadership of the Walton County Board of County Commissioners in establishing the Coastal Dune Lakes Advisory Board (CDLAB) (Ordinance 2002-02), this group may find this option most attractive. Ordinance 2002-02 provides a legal as well as a politically acceptable mode of action for Walton County's coastal dune lakes. The members of the CDLAB are effective (at least as effective as most advisory boards), and they are individuals (as specified in Ordinance 2002-02) with special qualifications through education, experience or history with the lakes that bring special knowledge, skills or abilities to the deliberations.

Approach:

If this option is selected, the CDLAB should consider different ways to reach out to the Walton County community to potentially garner more participation by citizens. The CDLAB is not guilty of some malfeasance or lack of caring as all meetings are publicly noticed and agendas are clear. Citizens all over Florida, however, are busy and typically shall not show at a public meeting unless the issue directly affects them. Most complaints within the Walton County community seem to be associated with a "lack of knowledge regarding meeting times" and "issues" before the CDLAB. Therefore, the CDLAB should consider developing a "target" list (groups or individuals that are interested in the Walton County dune lakes and their specific interest) that can be contacted directly when a potential issue of concern is to be brought before the CDLAB. Ordinance 2002-02 also provides for ex-officio members. Currently the groups holding ex-officio offices are: Florida Department of Environmental Protection, Florida Department of

Health, Florida Fish and Wildlife Conservation Commission, University of Florida/IFAS, U.S. Fish and Wildlife Service, Choctawhatchee Basin Alliance, and a private, ex-Walton County Official.

Option 2: Select the Coastal Dune Lakes Advisory Board of Walton County with an expansion of the ex-officio members or Technical Advisory Group.

Justification:

The primary advantage of selecting the existing Coastal Dune Lakes Advisory Board of Walton County (with some modifications) as the lead lake management group would be (as stated in Option 1) that the CDLAB could channel the agreed upon management approaches (getting something done) through the Walton County Planning Division directly to the Board of County Commissioners. In establishing the seven (7) member Coastal Dune Lakes Advisory Board (Ordinance 2002-02), the Board of County Commissioners recognized that there is a strong need for a diversity of representation and established language for adding ex-officio members (up to 10 members per Ordinance 2002-02) to the Coastal Dunes Advisory Board. This structure provides the greatest assurance that what is decided upon by the Coastal Dune Lakes Advisory Board is acceptable to most Walton County citizens and that if action is taken by the Board of County Commissioners, something will most likely happen.

The diversity of representation on the advisory board needs to be expanded to insure that all groups--for example the real estate industry or Topsail Hill State Park--are represented and that participating citizens receive needed technical advice. It is clear there is a wealth of scientific information available on the coastal dune lakes, but it is unrealistic for the citizens to become limnologists, oceanographers, meteorologists, or any other professional expert. Members of the CDLAB, however, can interpret technical information when presented to them.

Approach:

The Walton County Board of County Commissioners has appointed seven ex-officio members (and can expand that number up to 10 members per Ordinance 2002-02). As mentioned previously, a representative from the real estate industry or another business group could provide important insight for many future issues. Certainly, a representative from the State Park System might be an excellent addition given the importance of Topsail, Grayton, Deer, and Camp Helen state parks to the area.

The Florida Legislature recognized the importance of a technical advisory group (TAG) when it established the Harris Chain of Lakes Restoration Council (373.467 F.S.). The Florida Legislature, in establishing the Harris Chain of Lakes Restoration Council, created a TAG consisting of one representative each from the appropriate Water Management District, the Department of Environmental Protection, the Department of Transportation, the Florida Fish and Wildlife Conservation Commission, the Lake County Water Authority, the United States Army Corps of Engineers, and the University of Florida, each of whom shall be appointed by his or her respective agency, and each of whom, with the exception of the representatives from the Lake County Water Authority and the University of Florida, shall have had training in biology or another scientific discipline. For the CDLAB, it seems that for their TAG to function effectively, it will need to be chaired by a local organization familiar with the issues. At this point in time, Ms. Julie Terrell, Director of the Choctawhatchee Basin Alliance, would seem to be a good choice.

The Walton County Board of County Commissioners should be requested to contact the appropriate organizations to send a representative. If need be, they could seek help from the local Legislative delegation to determine if representatives from the state agencies can be assigned. While the mix used for the Harris Chain of Lakes Restoration Council will not be appropriate for the coastal dune lakes, representatives from the Northwest Florida Water Management District, the Department of Environmental Protection, and the Florida Fish and Wildlife Conservation Commission are needed. A representative from Walton County Public Works (storm water expertise) and the Planning & Development Division are also needed. Because there are excellent professionals at Okaloosa-Walton College, it is strongly recommended that a representative from that fine educational institution be appointed to CDLAB's TAG because they will have familiarity with the coastal dune lakes.

Issue 2: Outlet Management

To ensure that readers of this report are clear, we define the term "outlet" to mean the connection between the dune lake of concern and the Gulf of Mexico. This needs to be clarified further, because sometime water flows from the Gulf to the lake of concern, which could be considered an inlet. Conversely, the connection also flows from the lake to the Gulf making it an outlet. The term "outlet" is used here to discuss the connection between the lake and the Gulf despite the direction the water within the connection is flowing. The following is the current outlet status of the individual Walton County coastal dune lakes (see Table 1):

1) Stewart Lake - The historical outlet for this lake is closed, making Stewart Lake more of a reservoir than a functioning dune lake.

2) Horseshoe Lake – This lake has no real outlet to the Gulf, making it more of an isolated lake within the old historical dune habitats.

3) Fuller Lake – This lake has no direct connection to the Gulf, but flows into Morris Lake.

4) Morris Lake – This lake has an undeveloped natural outlet to the Gulf and was opened manually in response to pressure from the County concerning flooding issues following Hurricane Ivan.

5) Campbell Lake - This lake has an undeveloped natural outlet to the Gulf.

6) Stallworth - This lake has an undeveloped natural outlet to the Gulf and was reportedly affected by the operation of heavy machinery on/near the outfall following Hurricane Ivan.

7) Allen Lake – The outlet for this lake is not directly to the Gulf, but discharges down a ditch on the north side of CR 30A, into the Oyster Lake outlet and then finally to the Gulf.

8) Oyster Lake – The outlet for this lake has obstructions in the form of three adjacent box culverts and closer to Oyster Lake two adjacent round driveway culverts. There is also development (homes) within the historical sweep distance and the homes can potentially suffer damage due to outlet migration.

9) Draper Lake - This lake has a relatively undeveloped natural outlet to the Gulf.

10) Big Redfish Lake – This lake has an undeveloped natural outlet to the Gulf.

11) Little Red Fish Lake – This lake used to have an undeveloped natural outlet to the Gulf, but currently has a wide, straight outlet to the Gulf that was caused by dredging. Dredging was done to allow for hurricane debris removal.

12) Alligator Lake - This lake has an undeveloped natural outlet to the Gulf.

13) Western Lake – Grayton Lake, Western Lake and Western Northeast are all connected and have a relatively undeveloped natural outlet to the Gulf.

14) Eastern Lake – This lake has an undeveloped natural outlet to the Gulf. At the citizen's meeting, concern was expressed about the Worth Williams sand importation days prior to Hurricane Ivan that reportedly ended up in the outfall. Concern was expressed that this "sand" was moved into the lake and its outfall by Hurricane Ivan and has affected the opening of the outfall.

15) Tresca Lake – Tresca Lake, has no direct connection to the Gulf (like Fuller Lake), but flows into Little Deer Lake.

16) Little Deer Lake – This lake has no direct connection to the Gulf (like Fuller Lake), but flows into Deer Lake.

17) Deer Lake - This lake has an undeveloped natural outlet to the Gulf.

18) Camp Creek - This lake has a relatively undeveloped natural outlet to the Gulf.

19) Powell Lake – This lake is located in Walton and Bay Counties but the outfall is located entirely in Bay County and has a relatively undeveloped natural outlet to the Gulf.

Throughout discussions with all of the Walton County's coastal dune lakes stakeholders, one of the most debated issues is outlet management. The issues are: 1) How often should the outlets be open to the Gulf? 2) Should the outlet locations be fixed or allowed to migrate? and 3) What water level should the lakes be managed for? Some stakeholders believe the outlets should be managed regularly, maintaining certain water levels and constant outlet locations, while others believe the outlets should be left alone to open, close, and migrate naturally. There are extreme, moderate and conservative views on the Outlet Management issue, and the final decision on how best to manage the outlets will most likely be a political one. For this report, we attempt to provide the best available information on how the outlets function and what impacts the outlets have on the water quality and ecology of the dune lakes. Hopefully this information will be used in the future by decision-makers to help determine how to manage or how not to manage outlets of Walton County's coastal dune lakes.

The Coastal and Oceanographic Engineering Department of the University of Florida produced an excellent report describing the physical attributes of Florida Coastal Dune lakes, the mechanisms by which the dune lakes are connected to the Gulf, and the process of outlet migration (Browder and Dean 1998: Appendix V). We provide here a brief summary of this report, along with additional data, so the reader gains an understanding of the complicated natural process of the opening and closing of coastal dune lake outlets.

There are three main mechanisms by which a connection naturally opens between a dune lake and the Gulf of Mexico: 1) the water level in a lake rises to an elevation higher than the beach dune and simply overflows onto the beach, following the path of least resistance and forming a distinct channel via scour, 2) wave conditions from the Gulf side erodes the dune between the Gulf and the lake opening a channel, and 3) the lake's water level and the ground water level both rise sufficiently to saturate the sand between the lake and the Gulf. The third mechanism causes a condition in which the water can flow through the sand, destabilizing the dune, and eventually creating a channel. While these mechanisms are listed in order of probability, it is most likely that some combination of the three mechanisms works in concert to naturally open a connection between the Gulf and the lake. There are also many ways for humans to mechanically open a connection, which has occurred in the past to relieve flooding.

There are many environmental and physical factors that contribute to these outlet-opening mechanisms, including but not limited to:

1) Rainfall and water table (groundwater) elevation
2) Watershed area, lake morphometry (e.g., lake area, mean depth, volume), and hydrology (e.g., water level and flushing rate)
3) Outlet sweep distance (S) and separation distance (D)
4) Tidal elevation and frequency of storm surges

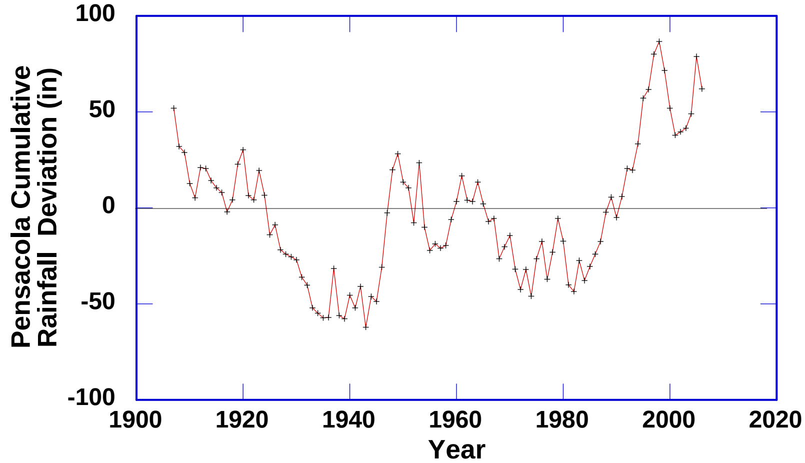
Rainfall and water table elevation

Rainfall and water table (groundwater) level are most likely the dominant factors impacting the frequency, duration, and size of outlet openings from the dune lakes to the Gulf of Mexico. When the water table is full, and it rains, then the water from each lake's watershed runs into the lake, filling it until the lake level reaches a sufficient elevation to breach the dune, causing an outlet to form. Most Florida residents understand the huge variability in rainfall across the state and through time. For example, from 1906 to 2006, the annual rainfall in Pensacola, Florida averaged 62.0 inches, but ranged from a low of 28 inches in 1954 to a high of 93.3 inches in 1953. Thus, the more variable the rainfall, the more variable outlet openings will be. Additionally, Florida groundwater supplies are similar to a sponge, such that multiple years of low rainfall tends to dry the sponge up, and then it takes multiple years of rainfall to fill it back up. Rainfall on top of a dry sponge is less likely to fill a lake and cause an outlet to form, but rainfall on a wet sponge can raise lake levels immediately and cause a breach in the dune.

This concept is depicted in Figure 2A and 2B where the cumulative rainfall deviation for a 100-year (Pensacola) and a 66-year (Eglin) record are plotted. The cumulative deviations in rainfall account for multiple years of dry or multiple years of wet conditions and are calculated by continuingly summing the difference between each year's total and the long-term average rainfall. Years where the cumulative deviation are above the zero line would tend to have higher water table levels and raise the lake level quicker with rainfall than those years below the zero line when water table levels tend to be lower and when it rains, it first has to fill the ground water (sponge), then the lake. So it would take a longer time for rainfall to raise the lake when the water table (sponge) is dry than when the water table is full. There are no continuous and sustained long-term records of the water table (groundwater) levels near Walton County's coastal dune lakes, but Figure 3 shows that the water table in Greenhead, Florida (approximately 25 miles northeast of the coastal dune lakes) fluctuated approximately 22 ft between 1963 and 2007. These data clearly show how variable the water table level can be in the Walton County area. Additionally, water table level and cumulative rainfall deficits are not always correlated, because groundwater pumping can significantly impact water table levels.

The importance of these rainfall and water table data are directly linked to citizen concerns about letting the coastal dune lakes' outlets function naturally. First, how do you define natural? Did natural conditions exist 10, 100, 1,000 or 10,000 years ago? This is especially difficult, because all lakes continue to age and change. Additionally, if "natural' is defined as 1,000 years ago, how can these conditions be determined with no historical record? With this in mind, one of the hardest parts about developing a comprehensive lake management plan is that most people think "natural" is defined by what they saw when they first visited (viewed) the lake. For many of the residents living in Walton County and living around the Walton County Dune lakes, this point in time is probably less than 10 years ago. Figures 2A, 2B and Figure 3 clearly show rainfall and groundwater cycles that far exceed a 10-year period. These cycles need to be recognized and strongly considered by TEAM participants (as well as other concerned individuals) before trying to define natural outlet conditions.

A



B

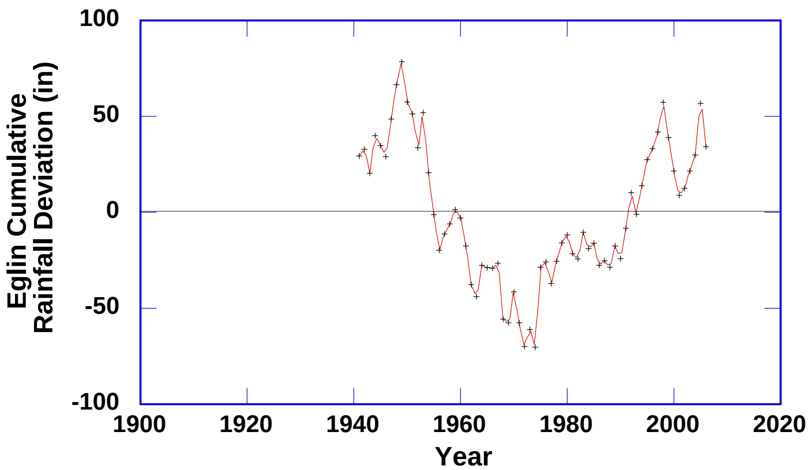


Figure 2. Long-term cumulative rainfall deviation for rainfall stations located in Pensacola (A, 100-year record) and Eglin Air Force Base (B, 66-year record).

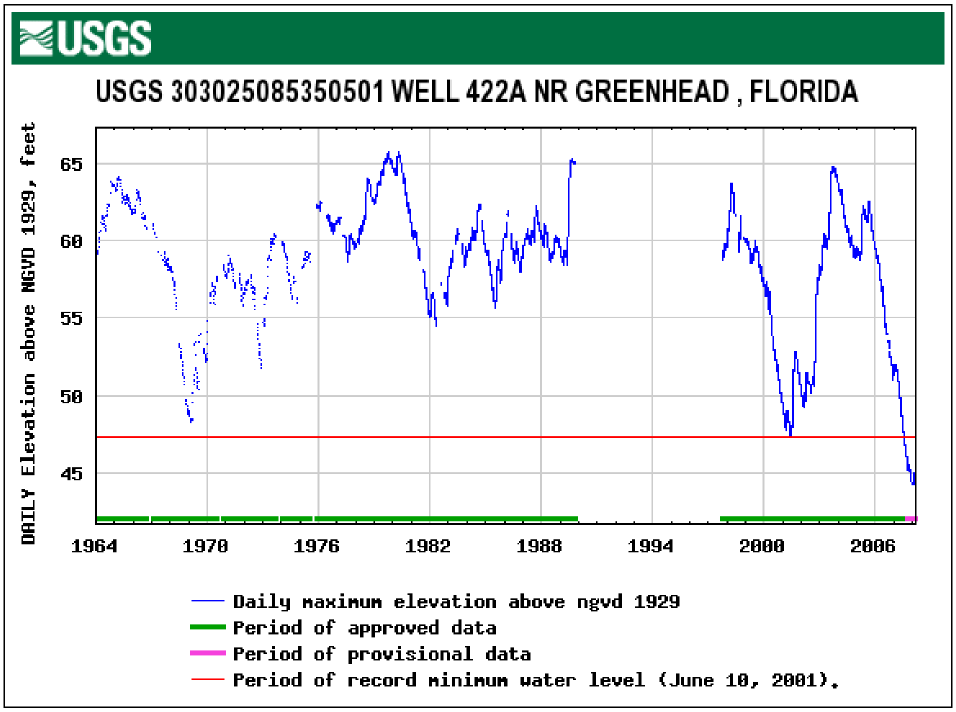
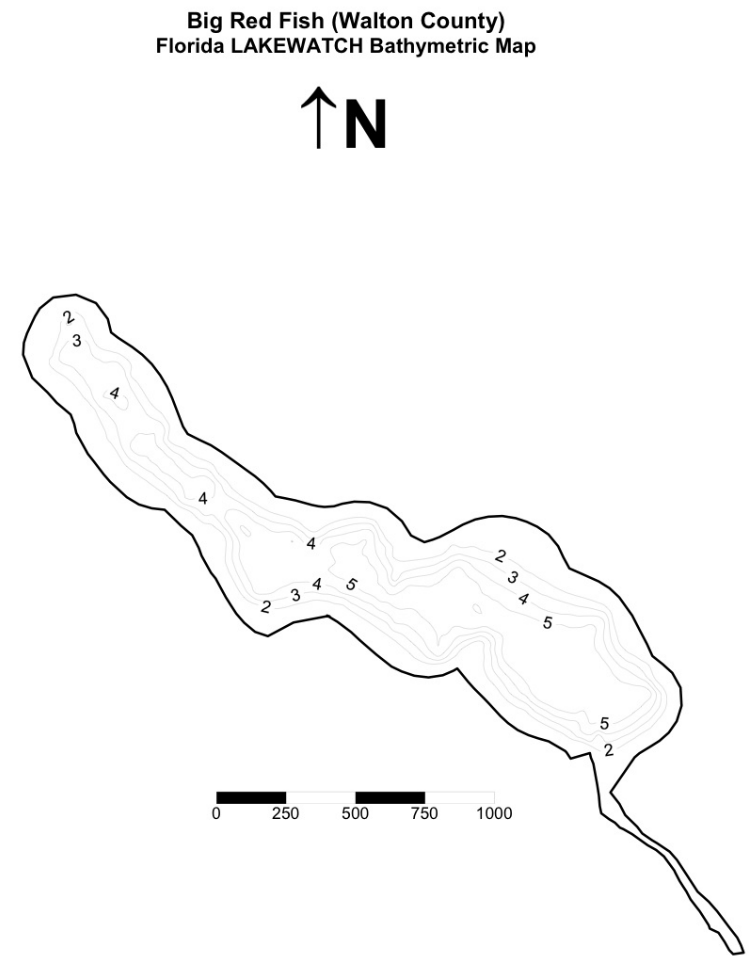


Figure 3. Long-term record for water table elevation in a well monitored by USGS and located in Greenhead, Florida approximately 25 miles northeast of Walton County's coastal dune lakes.

Watershed area, lake morphometry (e.g., lake area, mean depth, volume), and hydrology, (e.g., water level and flushing rate)

Morphology is the study of a lake basin's physical features (Florida LAKEWATCH 2001). A lake's watershed is the land area from which water flows into a lake. Drawing a line that connects the highest land elevations all the way around a lake is one way to delineate a watershed's boundary. A more accurate delineation would also include areas that are drained into the lake through underground pathways. In Florida, these might include drainage pipes or other man-made systems, seepage from high water tables, and flows from springs. Underground water flow in Florida always needs to be considered.

Morphometric parameters such as lake surface area and average depth of a lake can be best understood by looking at a map of the lake, preferably a map showing the depth contours of the bottom (called a bathymetric map, i.e., Figure 4). By combining the watershed area with the



Florida LAKEWATCH personnel created this map using differentially corrected global positioning equipment (GPS). Data were collected July 26, 2000. Scale and map contours are in feet and were generated using kriging technique in Surfer® software package (Golden CO). The center of the lake is located at Latitude 30 °20'16" and Longitude 86°11'37". On this date, the lake surface area was calculated at 28 acres (11 hectares). This is only an approximate bathymetric map and should not be used for navigation.[1]

[1]Map revised with new gridding procedures 2/10/05.

Figure 4. Bathymetric map of Big Red Fish Lake created by Florida LAKEWATCH in 2000.

annual average rainfall of approximately 62 inches per year (Pensacola, Florida), the volume of water entering a lake can be estimated. Dividing this entering water volume by the lake’s volume, which is calculated by multiplying lake area by mean depth, determines how many times per year the lake’s entire water volume exchanges, or a lake’s flushing rate.

The estimated flushing rates for Walton County’s coastal dune lakes are extremely variable (Table 2) ranging from 0.1 times per year in Campbell Lake to 18.9 times per year in Draper Lake, with an average of 7.5 times per year. Combining this variability with the variability in rainfall (Figure 2A and Figure 2B) provides evidence of how variable the opening and closing of the dune lake’s outlets can be, both over time and among the different lakes.

There are no reliable long-term records (20+ years) of outlet openings for the Walton County dune lakes. However, CBA volunteers sampling the Walton County Dunes lakes have kept sporadic records for the last four to six years (Table 3). On 17 dune lakes, the average percentage of sampling events in which the outlet was open was 24%, ranging from 0% at Lakes Allen and Fuller to 56% at Alligator Lake.

Table 2. Summary statistics and measurements of watershed areas (14 Walton County coastal dune lakes, Hartman and Associates, Inc. 2001), lake areas (15 Walton County Dune Lakes, Florida LAKEWATCH 2007), mean depths (17 Walton County coastal dune lakes, CBA unpublished data). These morphometric parameters were used with the average annual rainfall (62 inches) measured at Pensacola to calculate annual flushing rates for 14 lakes.

Lake	Watershed Area (acres)	Lake Area (acres)	Mean Depth (ft)	Flushing Rate for 62 in/yr rainfall
Allen	175.4	17.6	3.6	14.3
Alligator	95.0	15.9	4.8	6.5
Big Red Fish	294.5	22.8	5.2	12.8
Camp Creek	526.5	57.7	5.2	9.1
Campbell	20.9	109.9	11.6	0.1
Deer	341.7	41.8	9.3	4.5
Draper	476.9	28.3	4.6	18.9
Eastern	379.5	62.8	6.9	4.5
Eastern North	.	.	4.8	.
Fuller	107.0	49.5	5.5	2.0
Grayton	.	.	.	.
Little Red Fish	.	12.4	6.0	.
Morris	214.0	78.3	10.1	1.4
Oyster	138.8	22.0	5.7	5.7
Powell	1804.1	258.0	6.6	5.5
Stallworth	212.7	12.9	5.0	17.0
Western	679.7	171.0	7.1	2.9
Western Northeast	.	.	5.6	.
Average	390.5	64.1	6.4	7.5
Maximum	1804.1	258.0	11.6	18.9
Minimum	20.9	12.4	3.6	0.1

Table 3. Record of outlet openings on Walton County's coastal dune lakes over four to six years, recorded by CBA volunteers working with Florida LAKEWATCH. The percentage of time the outlet was open is calculated based on the number of times the outlet condition was recorded.

Lake		Start Date	End Date	Outlet Closed	Not Recorded	Outlet Open	Percent Open
Allen		2/10/03	10/30/07	34	8	0	0
	2003			6	0	0	
	2004			10	1	0	
	2005			6	0	0	
	2006			9	1	0	
	2007			3	6	0	
Alligator		2/10/03	12/9/07	18	3	27	56
	2003			5	0	6	
	2004			3	0	4	
	2005			5	1	3	
	2006			3	1	7	
	2007			2	1	7	
Big Red Fish		3/29/02	11/23/07	28	4	29	48
	2002			3	1	2	
	2003			6	0	3	
	2004			4	1	7	
	2005			3	1	7	
	2006			6	0	6	
	2007			6	1	4	
Camp Creek		3/18/02	11/1/07	22	15	13	26
	2002			0	1	0	
	2003			6	1	5	
	2004			4	2	5	
	2005			5	2	1	
	2006			5	3	1	
	2007			2	6	1	
Campbell		5/3/02	11/29/07	39	13	3	5
	2002			0	2	0	
	2003			8	1	3	
	2004			9	3	0	
	2005			7	2	0	
	2006			8	3	0	
	2007			7	2	0	

Table 3 (continued). Record of outlet openings on Walton County's coastal dune lakes over four to six years, recorded by CBA volunteers working with Florida LAKEWATCH. The percentage of time the outlet was open is calculated based on the number of times the outlet condition was recorded.

Deer		12/13/01	12/20/07	23	9	14	30
	2001			0	1	0	
	2002			1	5	0	
	2003			3	0	6	
	2004			6	0	3	
	2005			1	0	3	
	2006			7	2	0	
	2007			5	1	2	
Draper		2/25/03	12/22/07	35	3	8	17
	2003			7	0	4	
	2004			6	0	2	
	2005			8	0	1	
	2006			9	1	0	
	2007			5	2	1	
Eastern		12/20/01	12/21/07	32	8	24	38
	2001			1	0	0	
	2002			4	5	2	
	2003			3	0	9	
	2004			3	1	5	
	2005			4	0	3	
	2006			9	0	2	
	2007			8	2	3	
Eastern North		4/18/03	12/7/07	29	2	19	38
	2003			3	0	6	
	2004			6	0	3	
	2005			4	0	5	
	2006			9	0	3	
	2007			7	2	2	
Fuller				40	7	0	0
	2002			0	2	0	
	2003			12	0	0	
	2004			7	0	0	
	2005			7	0	0	
	2006			10	1	0	
	2007			4	4	0	

Table 3 (continued). Record of outlet openings on Walton County's coastal dune lakes over four to six years, recorded by CBA volunteers working with Florida LAKEWATCH. The percentage of time the outlet was open is calculated based on the number of times the outlet condition was recorded.

Little Red Fish		3/13/02	12/28/07	29	10	14	26
	2002			0	4	0	
	2003			6	0	5	
	2004			4	0	4	
	2005			5	0	3	
	2006			8	3	1	
	2007			6	3	1	
Morris		6/20/02	11/29/07	20	14	22	39
	2002			0	2	0	
	2003			2	1	8	
	2004			6	2	6	
	2005			0	3	6	
	2006			5	4	2	
	2007			7	2	0	
Oyster		2/2/02	10/30/07	27	12	7	15
	2002			0	1	0	
	2003			6	0	3	
	2004			9	1	1	
	2005			5	0	1	
	2006			6	3	1	
	2007			1	7	1	
Powell		8/8/02	12/9/07	28	3	22	42
	2002			0	1	2	
	2003			3	0	6	
	2004			4	0	7	
	2005			4	0	3	
	2006			9	0	3	
	2007			8	2	1	
Stallworth		3/22/02	12/10/07	37	11	9	16
	2002			0	2	0	
	2003			6	0	5	
	2004			8	2	2	
	2005			5	1	2	
	2006			8	4	0	
	2007			10	2	0	

Table 3 (continued). Record of outlet openings on Walton County's coastal dune lakes over four to six years, recorded by CBA volunteers working with Florida LAKEWATCH. The percentage of time the outlet was open is calculated based on the number of times the outlet condition was recorded.

Western	5/18/02	12/1/07	13	37	5	9
2002			0	3	0	
2003			0	12	0	
2004			2	8	1	
2005			3	3	4	
2006			6	4	0	
2007			2	7	0	
Western Northeast	5/18/02	12/1/07	25	17	10	19
2002			1	2	0	
2003			6	1	5	
2004			7	2	1	
2005			3	3	4	
2006			5	5	0	
2007			3	4	0	

In early 2008, a tremendous amount of rain fell on Walton County. Many parts of the county experienced rainfall exceeding 12 inches in a couple of weeks. This rainfall filled each dune lake and caused most of the functioning lake outlets to open to the Gulf (CBA personal observation). In some cases, the outflow was powerful enough to scour deep outlet channels. One example is Little Redfish, whose outlet channel was deep enough to lower the lake's water level quickly enough that CBA and LAKEWATCH offices received phone calls concerning the decrease in water volume within the lake. These are important observations suggesting that unrestricted dune lake outlets are functioning normally, depending on factors and mechanisms listed in this section. Additionally, it is difficult if not impossible to determine significant long-term changes in environmental conditions based on short-term observations. The problem comes with actually defining short-term and long-term in actual time units (months, years, decades, and/or centuries) relative to citizens living along and using the dune lakes.

If opening/closing records are kept in the future, a primary question that could be addressed is whether the dune lakes with the higher flushing rates tend to open more frequently then lakes with a low flushing rate.

Outlet sweep distance (S) and separation distance (D)

The historic sweep distance (S) describes the coastal shoreline distance affected by all previous identifiable outlet locations. This distance is determined by measuring a straight line from extreme limits of the interrupted dune line vegetation. The separation distance (D) represents the shortest distance from the main body of the dune lake to the lakeside of the enclosing dune shoreline. Figure 5 shows a schematic of Draper Lake's outlet, defining the sweep distance (S) and the separation distance to the Gulf of Mexico (D). Browder and Dean (1998) estimated the sweep distance for Draper Lake to be approximately 1,200 ft and the separation distance to be about 300 ft, suggesting that through the course of time this outlet has migrated back and forth in that 1,200 ft sweep distance.

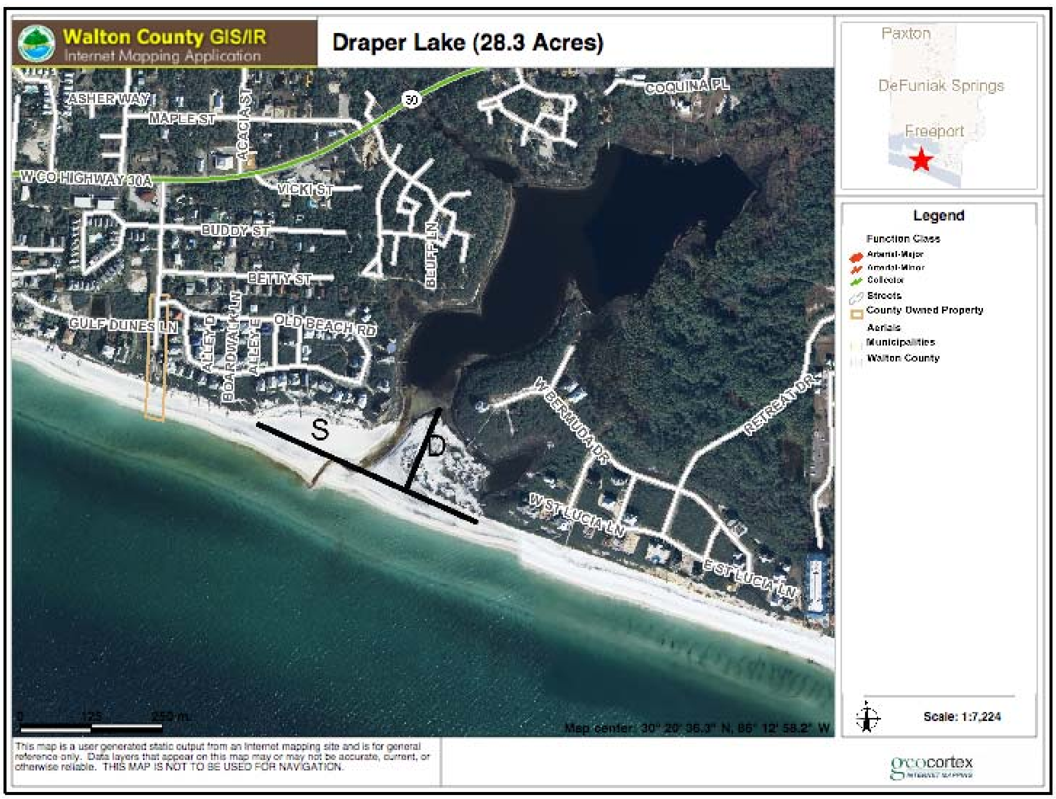


Figure 5. Schematic of Draper Lake's outlet defining the sweep distance (S) and the separation distance to the Gulf of Mexico (D).

The separation distance (D) for 14 Walton County dune lakes estimated by Browder and Dean (1998) ranges from 100 ft to 1050 ft with an average of about 500 ft (Table 4). Generally, the greater the separation distance, the more difficult it is for water to flow and cause an outlet to open. This basic fact is important, because the greater friction involved makes the outlet less hydraulically efficient. This again adds to the variability in determining the frequency and duration of outlet openings.

The sweep distance (S) for 14 of the Walton County dune lakes ranged from 150 ft to 3000 ft with an average of 1232 ft (Table 4). There are many physical factors that cause an outlet to migrate inside the area defined by the sweep distance; these are beyond the scope of this document, but they are documented well by several researchers (see Browder and Dean 1998). The major concern about the sweep distance is that the current outlets may someday swing to an extreme location either east or west and threaten (as already is the case) a nearby structure that has been built inside the historic sweep distance.

Table 4. Estimates of the sweep distance and separation distance for 14 of Walton County's coastal dune lakes (Browder and Dean 1998).

Lake	Sweep Distance (ft)	Separation Distance (ft)
Allen	150	100
Alligator	1200	700
Big Red Fish	1500	400
Camp Creek	2600	500
Campbell	.	.
Deer	1500	650
Draper	1200	300
Eastern	1000	500
Eastern North	1000	500
Fuller	.	.
Grayton	.	.
Little Red Fish	800	250
Morris	600	1050
Oyster	400	200
Powell	3000	800
Stallworth	400	300
Western	1900	900
Western Northeast		.
Average	1232	511
Minimum	150	100
Maximum	3000	1050

Tidal elevation and frequency of storm surges

It is easy to see how catastrophic hurricanes with their storm surges can dramatically change water chemistry of the coastal dune lakes and impact outlets. The huge amount of sand and saltwater being forced by wind over the beach changes everything, including the import of many forms of saltwater adapted flora and fauna. The sand will also tend to fill the current outlet and even increase the height of the dune, forcing a new outlet to be created following the mechanism discussed earlier (Browder and Dean 1998).

These sand deposits are also part of a newly emerging science called Paleotempestology whereby scientists determine the historical number of catastrophic storms that have breached the dunes (Liu and Fearn 1993). They do this by examining and counting sand layers in sediment cores that are taken from the coastal dune lakes. Each storm surge carries sand into the lake that leaves a record by forming a sand layer on the bottom. Sediment cores taken in several lakes from Florida (including Western Lake in Walton County) to Louisiana have indicated that catastrophic storms hit this Gulf Coast area approximately once every 300 years (Liu 2007). However, another scientist using a finer measure of organic layers estimated that a catastrophic hurricane hit an Alabama coastal lake once every 62 years during the last 700 years (Lambert et al. 2008). Regardless of the estimate, it is easy to see that this mechanism works on the order of centuries. However, smaller hurricane strikes that breach a lake's confining dune without leaving major sand layers probably occur on the order of decades.

Aside from major storm impacts, everyday tidal cycles can also impact the opening and closing of dune lake outlets (Nielsen 1992). Depending on the afore-mentioned factors of water table level and rainfall, the water level of coastal dune lakes generally exceeds the mean Gulf water level, causing a hydraulic gradient favoring the flow of water from the lake toward the Gulf. However, high tides and localized wave setup can raise the local water table near the beach face, actually reducing the hydraulic gradient between the dune lakes and the Gulf. At the same time, the waves are exerting force on individual sand particles at the beach face. This creates a situation in which the waves are both destabilizing the dune face and bringing sand in from the Gulf by a process called up drift. At some point, the hydraulic gradient that exists across the dune decreases to the point where wave action can more easily dislodge sand particles, leading to increased water flow toward the Gulf, and ultimately establishing a channel (outlet) between the two water bodies. It is at this time of low hydraulic gradient that the potential for saltwater to enter the lake is at its highest. It is to be noted, however, that the majority of times that an outlet is open, only freshwater will flow to the Gulf and no saltwater will flow from the Gulf to the lake.

Saltwater flow into the dune lakes is one of the major concerns voiced by citizens regarding outlet management. The fear is that the outlets of some dune lakes are not presently opening up "often enough" to maintain a brackish water condition in the dune lakes. The salinity (salt content) of several dune lakes has shown a continual decline, even though the outlets seem to be opening on a regular basis (see Issue 3: Water Quality—Salinity). This is probably because the conditions are just not right for water to flow from the Gulf of Mexico to the lakes. The diagram shown in Figure 6 shows the general schematic cross-section of a dune lake illustrating that the water level of the dune lake is generally higher than the mean Gulf surface water level. Therefore, unless the outlet opens and erodes the channel deep enough for a high tide to elevate the Gulf water level above lake levels, water from the Gulf will not enter into the lake. The lake will remain mostly fresh water! Additionally, the outlet generally stays open until the ocean's up drift brings sand in up to a level that stops the flow of water.

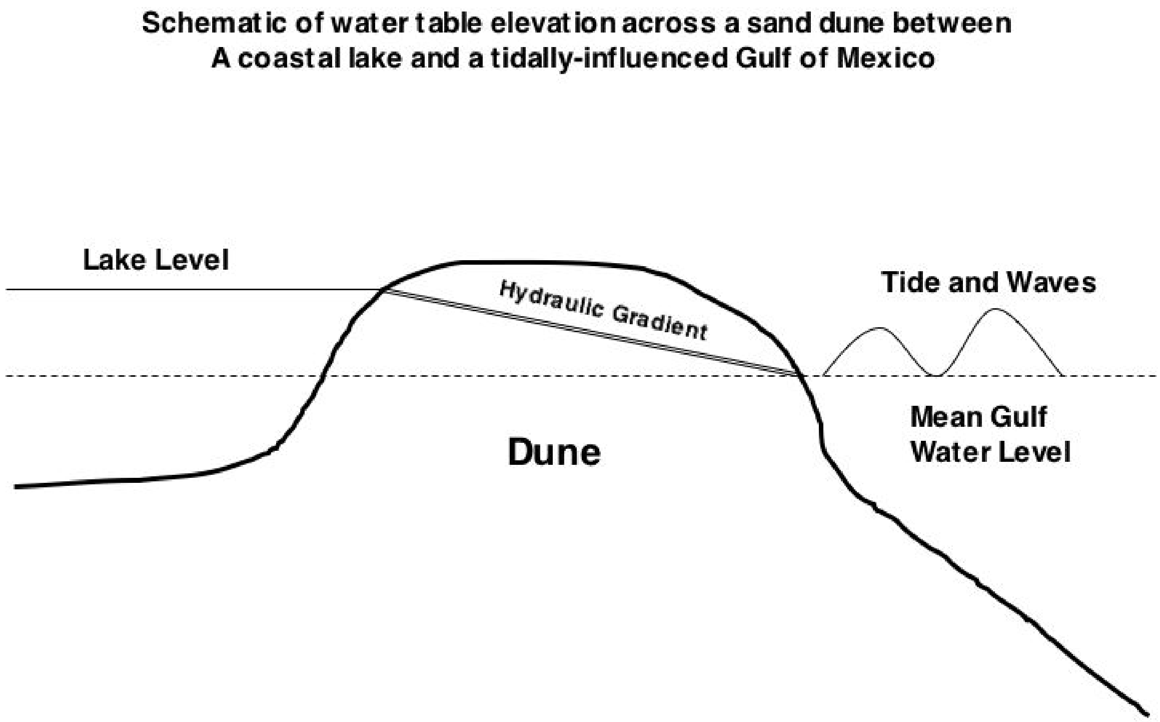


Figure 6. Schematic of water table elevation across a sand dune between a coastal dune lake and a tidally influenced Gulf of Mexico.

Summary of Potential Management Options for Issue 2: Outlet Management

Option 1: Monitor the dates and times of all dune lake outlet openings and closings, and collect information on rainfall, water table level, watershed area, and lake morphometry to help model the frequency, magnitude, and duration of outlet openings. These data need to be combined into a master database, continually updated as monitoring occurs and analyzed over time for trends.

Justification:

Information provided in the prior section shows that dune lake outlets open and close depending on rainfall, water table level, the physical aspects of the lake's watershed and lake morphometry. Much of this information is already available and recorded in the prior section and does not need to be re-created. Other data is already being monitored (e.g., rainfall) and just needs to be requested from Eglin Air Force Base to maintain a continuous database. However, data and some forms of monitoring to obtain continuous data on some lakes is lacking, including: watershed areas, good bathymetric maps for calculating lake volumes, stage gauges in the lakes to monitor water levels and local wells to monitor groundwater levels. When this information is collected, combined in a database and continually examined over time, it will help in determining if there are changes in the functioning of the dune lake outlets as Walton County's population continues to grow.

Approach:

Watershed areas and land use information are already available for all of the Walton County dune lakes from GIS (Geographical Information Systems) maps used by Hartman and Associates (2001) when they wrote the Walton County Stormwater Master Plan. Personnel from CBA should acquire these data and maintain them in a master database. Similarly, rainfall-monitoring data are available from stations in Pensacola and Eglin Air Force Base. These data should also be acquired by CBA personnel, added to the master database and continually updated for analyses.

The nearest well to the Walton County dune lakes that is continuously monitored for water level by USGS (United States Geologic Survey) is in Greenhead, Florida about 25 miles northeast of the nearest dune lake. CBA personnel should work with Walton County staff to determine if other wells exist closer to the dune lakes that could be monitored for water level. If other wells exist, CBA personnel should find some way of monitoring the water levels on a regular basis. If a closer well does not exist, then CBA should work with Walton County for funds to sink a well for water level monitoring purposes. These data when acquired should again be added to the master database.

Few staff gauges are positioned in the Walton County dune lakes for recording water levels. CBA personnel should work with Walton County staff to acquire funds to put “good” staff gauges in each of the dune lakes. These gauges should be calibrated to mean sea level for comparisons with Gulf water levels. Florida LAKEWATCH and CBA volunteers who sample the lakes could regularly record the water levels, adding them to their monthly data sheets. At this time the volunteers could also record if the outlet was open or closed. These data can be maintained by Florida LAKEWATCH personnel and sent to CBA to be added to the master database. These water level data will not only be useful for determining the hydrology of the dune lakes but also in documenting the water levels that begin to cause residential flooding for future management actions. Perhaps more importantly, when future residents and lake-users raise similar issues/concerns in the future there will be facts that future decision-makers can analyze.

Florida LAKEWATCH has already developed bathymetric maps for six of the Walton county dune lakes. These maps, however, were created in the year 2000 and LAKEWATCH has since upgraded the methodology used to create bathymetric maps. It is recommended that if money becomes available, LAKEWATCH is contracted to create new bathymetric maps for each of the Walton County’s coastal dune lakes calculating lake areas, lake volumes and mean depth for the master database maintained by CBA.

The Community Collaborative Rain, Hail, and Snow (CoCoRaHas) network is a volunteer monitoring effort to document various climatic data across the United States. CBA is assisting the Florida coordinator in the implementation of this program locally in Walton County.

Volunteers need to be found near the coastal dune lakes to obtain rainfall data near the lakes. CoCoRaHas data is entered into the national database via the Internet. These data should also be acquired by CBA personnel, added to the master database and continually updated for analyses.

Option 2: Walton County staff should identify property adjacent to the dune lakes outlets, but located in the historical sweep distance. The Walton County Commission should be advised to buy and preserve these properties if it is possible to leverage monies with existing conservation groups, private individuals or state/federal government. Where money is not available, Walton County should strive to prohibit any additional building of major permanent structure in the historical sweep area. This may require legal adjustments to building restrictions and strict enforcement of permitting that is already outlined in the County's Land Development Code. However, private property rights must always be considered.

Justification:

Research from several investigators has shown that the outlets for the dune lakes have migrated east and west for thousands of years and that they will likely continue to do so. Because of this, any construction within the sweep area stands a high chance of structural damage. County purchase of this land will allow the outlets to function as naturally as possible into the future, which was one of the most voiced opinions by stakeholders during the original issue defining meetings.

The Florida Department of Environmental Protection (FDEP) develops maps identifying Coastal Construction Control Lines (CCCL). These maps identify the location of the CCCL, which delineates the State's jurisdiction in coastal matters. Construction seaward of these lines requires a special permit from FDEP. Browder and Dean (1998) noted that the CCCL in the vicinity of Walton County's coastal dune lakes has generally been diverted landward of the historical sweep areas, reducing (but not eliminating) the threat of structural damage due to migration of the outlet. However, current and potential development seaward of the CCCL does exist in many of the sweep areas, thus the potential for structural damage still exists.

Approach:

Walton County Commissioners should allocate county funds or seek private, state and/or federal funds (e.g., Water Management District, Nature Conservancy, etc.) for purchasing land adjacent to the Walton County coastal dune lakes' outlets.

The Walton County Land Development Code now enforces a 300 ft zone of protection for coastal dune lakes (Section 4.02.03) and a 50 ft buffer around each of the coastal dune lake outlets. However, the identified sweep area for many of the dune lakes exceeds these protection areas. Therefore, Walton County should consider changing the building restriction of the Land Development Code to include the entire zone of the sweep areas, but set it for individual lakes.

Option 3: Install deep wall barriers into the sand on private property to reduce outlet migration.

Justification:
Private property and associated permanent structures already exist in the historical sweep areas of some dune lakes. Property lines immediately adjacent to the outlets should be identified, and the County or other appropriate governmental agencies should partner with adjacent land owners to place "deep" wall barriers (e.g. aluminum bulkheads) into the sand on the inside of private property lines to help retard and even prevent outlets from sweeping into and destroying private property. If this approach is not adopted, there is the constant danger of "midnight raiders" fixing the problem.

Approach:

The Walton County Public Works Department could assess the feasibility of this option. Public Works has the engineers and equipment to successfully complete such an undertaking, but more importantly, the personnel have experience working on the mobile dune sands.

Issue 3: Water Quality

Managing water quality of Walton County's coastal dune lakes, as with all lakes, is a difficult objective, primarily because defining "water quality" itself is a difficult task. Water quality can only be defined after first establishing a desired use for a given water body. For example, a large lake-user survey conducted in Florida (Hoyer et al. 2006) shows that the number one defined use of a lake by people is to sit and enjoy the lake (aesthetics) and the number two use is fishing (Figure 7). Here is an example of the most common lake management problem, that is: *A Lake Cannot Be All Things to All People*. A high value on aesthetics in lake management generally means a desire for clear water, which requires oligotrophic conditions, while the best fishing occurs in productive water, which requires eutrophic (not usually clear water) conditions. These terms (oligotrophic/eutrophic) will be explained later in this section. Because of this common lake management problem, the terms water chemistry and water quality are not always interchangeable.

Stakeholders identified water quality as a major issue for the dune lakes with a major concern that the lakes may be changing from their natural conditions due to the large population growth in the area of the coastal dune lakes and in all of Walton County (Figure 1). Generally, as human populations increase in a watershed, so do potential inputs of various substances due to storm water, septic tanks, lawn care and other activities. For this section of the report, the major three questions that will be addressed under the water quality issue are: 1) Are the trophic states of the Walton County dune lakes changing? 2) Is salinity significantly changing in the dune lakes? and 3) Are there potential bacterial and/or chemical contaminations in the dune lakes?

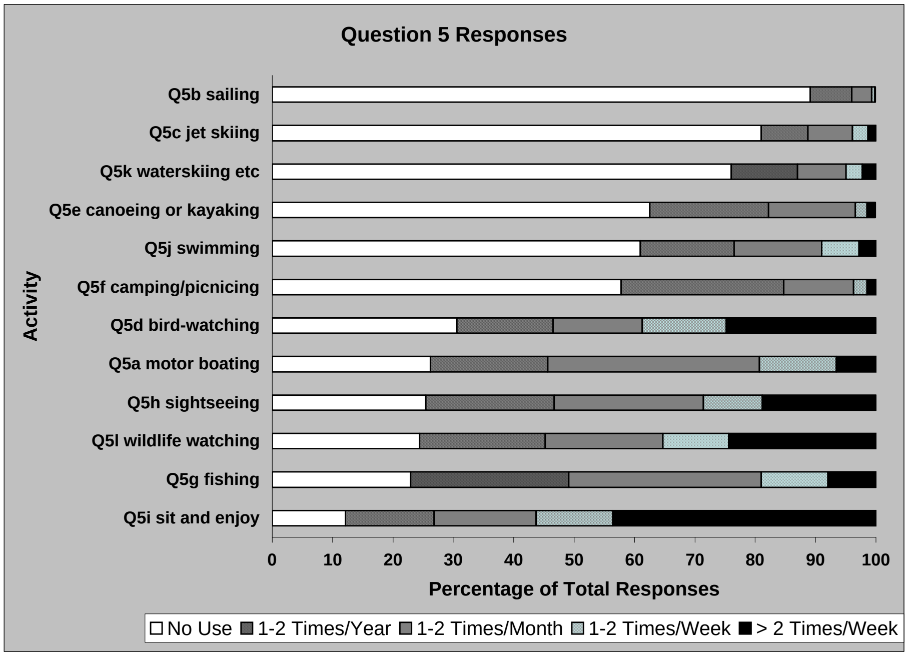


Figure 7. Summary of the percentage of time lakes were utilized by survey respondents (984) for each of 12 different lake activities. This survey was conducted in Florida, but responses are similar to other surveys conducted around the United States.

Lake Trophic Status

Trophic state is defined as "the degree of biological productivity of a water body." Scientists debate exactly what is meant by biological productivity, but it generally relates to the amount of algae, aquatic macrophytes, fish and wildlife a water body can produce and sustain. The adjectives denoting each of the trophic states, from the lowest productivity level to the highest, are:

1) Oligotrophic
2) Mesotrophic
3) Eutrophic
4) Hypereutrophic

The four water quality parameters that are generally used by professionals to assign lake trophic status are total phosphorus, total nitrogen, chlorophyll, and Secchi depth. There are several types of lake trophic state classification systems that have been developed (e.g., fixed boundary classes, open boundary, trophic state indices). Forsberg and Ryding (1980) developed the following trophic state classification system, which is used by Florida LAKEWATCH (Table 5).

Table 5. Trophic State Classification system used by the Florida LAKEWATCH program (Forsberg and Ryding 1980).

	Trophic State Parameters			
Trophic State	Total Phosphorus (µg/L)	Total Nitrogen (µg/L)	Chlorophyll (µg/L)	Secchi (m)
Oligotrophic	< 15	< 400	< 3	> 4.0
Mesotrophic	15 - 25	400 – 600	3-7	2.5 - 4.0
Eutrophic	26 - 100	600 – 1500	7-4	1.0 - 2.5
Hypereutrophic	> 100	> 1500	> 40	< 1.0

CBA coordinates the Florida LAKEWATCH program in Walton County. CBA and LAKEWATCH volunteers have been sampling trophic state parameters (total phosphorus, total nitrogen, chlorophyll, and Secchi disk depth) on the coastal dune lakes for different lengths of time. Currently 15 of the coastal dune lakes are actively sampled (Table 6).

Table 6. Period of record and number of days that Florida LAKEWATCH has analyzed trophic state parameters for the different Walton County coastal dune lakes.

County	Lake	Days	Start	Last Record
Bay	Powell	139	2/11/91	8/11/07
Walton	Allen	41	2/10/03	8/14/07
Walton	Alligator	61	10/24/00	9/2/07
Walton	Big Red Fish	80	7/27/98	9/29/07
Walton	Camp Creek	159	11/8/92	9/27/07
Walton	Campbell	76	8/29/95	8/21/07
Walton	Deer	72	7/27/98	8/19/07
Walton	Draper	51	10/29/96	8/30/07
Walton	Eastern	103	1/13/97	9/25/07
Walton	Eastern North	48	4/18/03	9/5/07
Walton	Fuller	45	6/17/02	8/14/07
Walton	Grayton	88	7/17/99	7/28/07
Walton	Little Red Fish	50	3/13/02	9/15/07
Walton	Morris	56	6/20/02	8/21/07
Walton	Oyster	47	10/27/01	8/9/07
Walton	Stallworth	56	11/16/01	8/20/07
Walton	Stewart	2	2/27/03	3/26/03
Walton	Western	71	11/1/96	7/14/07
Walton	Western Northeast	58	1/26/99	9/1/07

The reason that total phosphorus concentrations can be used to classify the trophic status of lakes is that phosphorus is generally the nutrient that limits growth of algal populations (the Limiting Nutrient Concept). Such algal populations are usually the major source of primary production, forming the base of the aquatic food chain. The *limiting nutrient* is a chemical necessary for plant growth — but available in smaller quantities than needed for algae to increase their abundance. Once the limiting nutrient in an aquatic system is exhausted, algae stop growing. If more of the limiting nutrient is added, larger algal populations will result until their growth is again limited by nutrients or by other limiting environmental factors. Chlorophyll is generally the preferred parameter (easier than counting algae under a microscope) used to define trophic status, because it is an inexpensive indirect measure of algal biomass/abundance. Secchi depth is generally an indirect measure of algal abundance when the algae are the major factor determining water clarity/transparency. Thus, all four parameters can be used as measures of trophic status, because they are each correlated in many waters to biological production.

Forsberg and Ryding's (1980) trophic state classification system, in accordance with Florida LAKEWATCH data on total phosphorus, total nitrogen, and chlorophyll, suggests that the majority of Walton County's coastal dune lakes would be classified as oligotrophic or mesotrophic, which are generally considered trophic states unimpaired by cultural eutrophication in Florida (Table 7A through Table 7D). These data are consistent with data from the Lake Region and geology of the area where Walton County's coastal dune lakes reside (Griffin et al. 1997).

Table 7A. Mean (average), minimum and maximum total phosphorus (μg/L) concentration measured in Walton County's coastal dune lakes for the period of record and number of sampling days listed in Table 6. Trophic state classifications listed in the Table are based on Forsberg and Ryding (1980). Canfield (1981) collected additional data on Oyster Lake and Western Lake on three separate dates in 1980 and these data are also provided.

	Total Phosphorus (μg/L)			
Lake	Mean	Minimum	Maximum	Trophic State
Allen	17	6	44	Mesotrophic
Alligator	11	5	31	Oligotrophic
Big Red Fish	14	4	35	Oligotrophic
Camp Creek	8	4	18	Oligotrophic
Campbell	6	1	14	Oligotrophic
Deer	11	4	20	Oligotrophic
Draper	17	7	55	Mesotrophic
Eastern	13	6	36	Oligotrophic
Eastern North	15	8	33	Oligotrophic
Fuller	12	5	18	Oligotrophic
Grayton	19	6	225	Mesotrophic
Little Red Fish	19	6	63	Mesotrophic
Morris	8	4	13	Oligotrophic
Oyster	82	28	203	Eutrophic
Oyster (Canfield 1981)	34	26	41	Eutrophic
Powell	18	7	149	Mesotrophic
Stallworth	18	4	51	Mesotrophic
Stewart	418	364	472	Hypereutrophic
Western	7	3	25	Oligotrophic
Western (Canfield 1981)	6	2	11	Oligotrophic
Western Northeast	7	3	14	Oligotrophic

Table 7B. Mean (average), minimum and maximum total nitrogen (µg/L) concentration measured in Walton County's coastal dune lakes for the period of record and number of sampling days listed in Table 6. Trophic state classification listed in the Table is based on Forsberg and Ryding (1980). Canfield (1981) collected additional data on Oyster Lake and Western Lake on three separate dates in 1980 and these data are also provided.

	Total Nitrogen (µg/L)			
Lake	Mean	Minimum	Maximum	Trophic State
Allen	801	557	2030	Mesotrophic
Alligator	579	310	1837	Mesotrophic
Big Red Fish	380	53	773	Oligotrophic
Camp Creek	383	197	860	Oligotrophic
Campbell	422	83	890	Mesotrophic
Deer	441	280	693	Mesotrophic
Draper	415	200	1027	Mesotrophic
Eastern	271	123	533	Oligotrophic
Eastern North	320	170	633	Oligotrophic
Fuller	779	230	1517	Mesotrophic
Grayton	344	123	1793	Oligotrophic
Little Red Fish	614	293	1143	Mesotrophic
Morris	589	220	980	Mesotrophic
Oyster	705	527	1497	Mesotrophic
Oyster (Canfield 1981)	548	475	633	Mesotrophic
Powell	364	175	725	Oligotrophic
Stallworth	489	143	2460	Mesotrophic
Stewart	1250	1137	1363	Mesotrophic
Western	263	97	497	Oligotrophic
Western (Canfield 1981)	289	225	375	Oligotrophic
Western Northeast	283	107	540	Oligotrophic

Table 7C. Mean (average), minimum and maximum chlorophyll (µg/L) concentration measured in Walton County's coastal dune lakes for the period of record and number of sampling days listed in Table 6. Trophic state classification listed in the Table is based on Forsberg and Ryding (1980). Canfield (1981) collected additional data on Oyster Lake and Western Lake on three separate dates in 1980 and these data are also listed.

	Chlorophyll (µg/L)			
Lake	Mean	Minimum	Maximum	Trophic State
Allen	9	1	67	Eutrophic
Alligator	5	1	35	Mesotrophic
Big Red Fish	6	1	32	Mesotrophic
Camp Creek	4	0	21	Mesotrophic
Campbell	2	0	10	Oligotrophic
Deer	6	1	26	Mesotrophic
Draper	7	2	25	Mesotrophic
Eastern	4	1	26	Mesotrophic
Eastern North	6	2	24	Mesotrophic
Fuller	5	0	16	Mesotrophic
Grayton	4	0	18	Mesotrophic
Little Red Fish	7	0	19	Mesotrophic
Morris	3	1	19	Oligotrophic
Oyster	7	0	30	Mesotrophic
Oyster (Canfield 1981)	4	3	7	Mesotrophic
Powell	4	1	16	Mesotrophic
Stallworth	8	0	80	Eutrophic
Stewart	63	48	78	Hypereutrophic
Western	2	0	6	Oligotrophic
Western (Canfield 1981)	1	1	2	Oligotrophic
Western Northeast	2	0	5	Oligotrophic

Table 7D. Mean (average), minimum and maximum Secchi depth (m) measured in Walton County's coastal dune lakes for the period of record and number of sampling days listed in Table 6. Trophic state classification listed in the Table is based on Forsberg and Ryding (1980). Canfield (1981) collected additional data on Oyster Lake and Western Lake on three separate dates in 1980 and these data are also listed.

	Secchi Depth (m)			
Lake	Mean	Minimum	Maximum	Trophic State
Allen	0.7	0.4	1.1	Hypereutrophic
Alligator	0.7	0.3	1.4	Hypereutrophic
Big Red Fish	1.1	0.4	2.4	Eutrophic
Camp Creek	1.2	0.4	2.2	Eutrophic
Campbell	2.1	0.6	4.2	Eutrophic
Deer	1.0	0.5	1.6	Eutrophic
Draper	1.0	0.4	2.1	Eutrophic
Eastern	1.7	0.4	2.5	Eutrophic
Eastern North	1.4	0.5	2.6	Eutrophic
Fuller	0.6	0.3	1.8	Hypereutrophic
Grayton	1.4	0.6	2.1	Eutrophic
Little Red Fish	0.6	0.3	1.1	Hypereutrophic
Morris	0.9	0.4	2.8	Hypereutrophic
Oyster	0.8	0.2	1.5	Hypereutrophic
Powell	1.8	0.4	3.4	Eutrophic
Stallworth	1.2	0.4	2.1	Eutrophic
Stewart	0.5	0.5	0.6	Hypereutrophic
Western	1.5	0.6	2.9	Eutrophic
Western Northeast	1.5	0.5	2.5	Eutrophic

Lake trophic status and general water chemistry in lakes throughout the world is determined primarily by the geology, soils, hydrology, vegetation, and the climate of the area where a lake exists. Using this information and measured water chemistry, Griffith et al. (1997) defined 47 lake regions in Florida, which are described in a final report, *Lake Regions of Florida*, published by the U.S. EPA (EPA/R97/127). Walton County's coastal dune lakes fall into the Gulf Coast Lowlands lake region. The geology in this Lake Region is dominated by sand dunes and well-sorted fine sand of the Pleistocene. Walton County's coastal dune lakes lie in the Coastal Strip divisions of the Apalachicola Delta District. The trophic status of lakes in this geology and Lake Region are most often classified by professionals as oligotrophic to mesotrophic.

The Secchi depth data could be used by professionals to suggest that the dune lakes are all eutrophic to hypereutrophic (Table 7D). However, these trophic state classifications would be erroneous because of the unique high true color values (indicator of dissolved organic matter) measured in Walton County's coastal dune lakes. The average color value for Walton County's coastal dune lakes is 99 Platinum-Cobalt units (Pt-Co), which appears tea or coffee colored, but individual lake values range from 29 (slightly stained) to 234 (black) Pt-Co units (Table 8). The average color value measured for Florida lakes (actual measurements from 1,065 Florida lakes) is 45 Pt-Co units (unpublished Florida LAKEWATCH data). Additionally, Figure 8A and Figure 8B show that color, not chlorophyll (the indicator of algal biomass) is the dominant factor determining the water transparency (Secchi depth) in the Walton County dune lakes. Therefore, Secchi depth is not a good parameter for determining trophic state of the dune lakes, because it violates the assumed relationship between chlorophyll and Secchi that Forsberg and Ryding (1980) and others have used when developing trophic state classification systems.

Table 8. Mean (average), minimum and maximum Color (Pt-Co Units) measured in Walton County's coastal dune lakes for the period of record and number of sampling days listed.

				Color (Pt-Co Units)		
Lake	Start Date	Last Record	Number of Samples	Mean	Minimum	Maximum
Allen	2/10/03	4/12/07	15	144	63	290
Alligator	1/8/01	1/30/07	21	221	34	477
Big Red Fish	1/14/01	1/30/07	20	105	21	377
Camp Creek	1/16/01	1/1/07	21	71	13	346
Campbell	9/5/02	2/20/07	20	29	0	88
Deer	1/22/01	1/25/07	18	127	49	251
Draper	3/26/03	11/13/06	14	110	23	322
Eastern	1/27/01	1/23/07	20	34	3	191
Eastern North	4/18/03	1/23/07	15	57	16	202
Fuller	1/29/03	2/10/07	14	151	3	372
Grayton	1/22/01	10/28/06	23	62	23	157
Little Red Fish	3/13/02	4/30/07	21	234	51	520
Morris	10/19/02	8/15/06	18	106	12	208
Oyster	10/27/01	1/26/07	16	172	54	311
Powell	7/15/01	4/14/07	39	35	14	113
Stallworth	2/15/02	1/13/07	19	53	20	122
Stewart	2/27/03	2/27/03	1	32	32	32
Western	1/17/01	1/3/07	18	62	12	196
Western Northeast	1/11/02	1/3/07	16	79	14	216

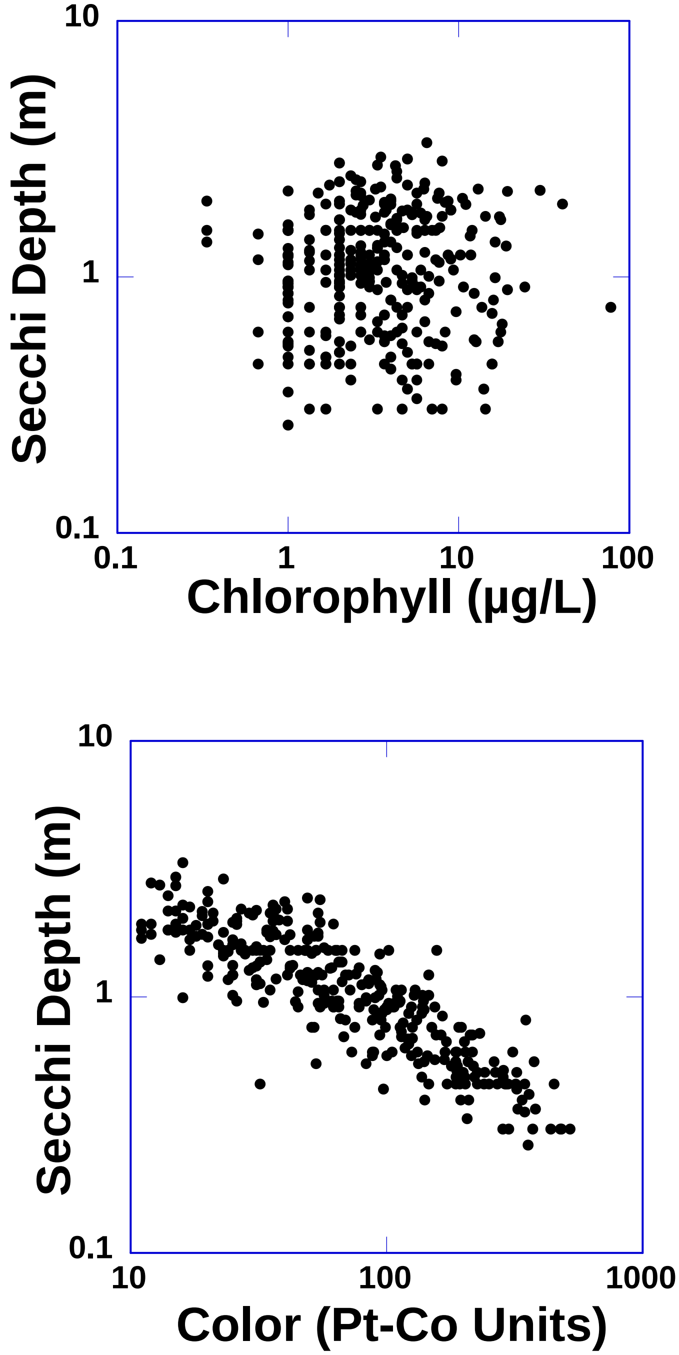


Figure 8. Relationships between Secchi depth and chlorophyll (Top), and Secchi depth and color (Bottom) for Walton County's coastal dune lakes using Florida LAKEWATCH data.

In most Florida freshwater lakes, the limiting nutrient is believed to be phosphorus. However, in watersheds where soils contain sizeable deposits of phosphorus, nitrogen may be the limiting nutrient. Generally, when the ratio of total nitrogen to total phosphorus (by weight) falls below 10 then nitrogen becomes the limiting nutrient (Sakamoto 1966). In the coastal dune lakes the average ratio of nitrogen to phosphorus is 39 (Table 9). Therefore total phosphorus is probably the limiting nutrient for each of the coastal dune lakes.

As mentioned earlier, in response to the stakeholders' concern for water quality, we investigated the question: Is the trophic status of Walton County's coastal dune lakes changing? This is a difficult question to answer, because no one really knows how long the period of record must be to show a significant trend in lake trophic status. Fortunately, Florida LAKEWATCH maintains a substantial period of record on the trophic state parameters of Walton County's coastal dune lakes, with an average number of 67 sampling days, ranging as low as 2 days for Stewart Lake and as high as 139 days for Lake Powell (Table 6). We used these data and two different methods in combination in trying to determine if there is a trend in the lake trophic status of individual Walton County coastal dune lakes.

Table 9. Mean (average), minimum and maximum nitrogen / phosphorus ratio measured in Walton County's coastal dune lakes using the Florida LAKEWATCH data for the period of record and number of sampling days listed.

Lake	Start Date	Last Record	Number of Samples	Nitrogen / Phosphorus Ratio Mean	Minimum	Maximum
Allen	2/10/03	11/29/07	44	58	33	182
Alligator	10/24/00	1/13/08	65	57	19	240
Big Red Fish	7/27/98	11/23/07	82	29	10	66
Camp Creek	11/8/92	1/29/08	164	52	19	132
Campbell	8/29/95	1/15/08	80	68	36	240
Deer	7/27/98	2/12/08	76	45	24	84
Draper	10/29/96	1/28/08	56	27	12	76
Eastern	1/13/97	1/10/08	107	24	12	50
Eastern North	4/18/03	1/10/08	52	25	11	60
Fuller	6/17/02	1/27/08	49	66	29	126
Grayton	7/17/99	7/28/07	88	23	7	63
Little Red Fish	3/13/02	1/30/08	55	41	13	93
Morris	6/20/02	1/15/08	60	75	32	160
Oyster	10/27/01	1/22/08	51	12	4	28
Powell	2/15/03	2/10/08	51	28	10	57
Stallworth	11/16/01	2/15/08	62	29	12	67
Stewart	2/27/03	3/26/03	2	3	3	3
Western	11/1/96	12/22/07	76	40	18	119
Western Northeast	1/26/99	1/12/08	62	42	16	78
			Average of all coastal dune lakes:	39		

The objective of long-term trend analyses is to determine if any significant changes are occurring in lake trophic state parameters (total phosphorus, total nitrogen, chlorophyll and Secchi depth) within individual lakes over time. Many different statistical procedures can be used to analyze data for temporal trends—some are more complicated than others. The first method we used follows the procedures of Burns et al (1999) who successfully examined temporal trends in 17 New Zealand lakes. The second method used calculates normal background variance for Florida lakes, as defined by Terrell et al. (2000), to determine if trophic state variables in individual lakes are fluctuating more than normal background variability.

Method 1- Previous analyses of Florida LAKEWATCH data throughout Florida have shown that there is considerable seasonal variation (spring, summer, fall and winter) in lake trophic state parameters (Brown et al. 1998). This seasonal variation can mask long-term changes over time (temporal) in these parameters. Therefore, the first step in determining if temporal changes are occurring is to look for seasonal patterns.

If a seasonal pattern is evident, it is accounted for prior to the long-term temporal analyses using a method modified from Burns et al. (1999). They used similar water quality parameters as the Florida LAKEWATCH program (monthly water samples of total phosphorus, total nitrogen, chlorophyll and Secchi depth) to examine the water quality in 17 New Zealand lakes. After seasonality is removed from the data, regression analyses are used to determine if a temporal trend is occurring over time. If no seasonality is found then, regression analysis is used on the original data (no statistical transformations) to determine if a temporal trend is occurring over time.

Method 2 - Seasonal and long-term temporal variability in trophic state variables can be considerable and is often driven by natural environmental factors like climatic changes. Terrell et al. (2000) quantified this variability in a population of 71 Florida lakes that showed no significant temporal seasonal trend. They calculated the 95th percentile of normal background variance of the long-term monthly means for the four trophic state parameters measured by Florida LAKEWATCH. For these Florida lakes, the normal background variance at the 95% confidence interval for total phosphorus was 48%, total nitrogen was 43%, chlorophyll was

103% and Secchi depth was 48% of the long-term lake average of all monthly averages. Using these confidence intervals for each parameter and the actual measured values of other lakes, temporal trends can be evaluated for each of the trophic state parameters by visual observation of the plotted data values in each graph. When substantially more than five percent of the data points fall outside of the confidence intervals at either end of the period of record, there is a potential significant time trend occurring.

Appendix VI shows plots of the four major trophic state parameters (total phosphorus, total nitrogen, chlorophyll, and Secchi depth) versus actual date the samples were taken for each of Walton County's coastal dune lakes, using Florida LAKEWATCH data collected during the period of record listed in Table 6. The data are fitted with a regression line and all of the data are bracketed with lines that define natural background variance (Terrell et al. 2000).

Tables 10A through 10D summarize the trophic state trend analyses for the Walton County dune lakes. Examining these analyses shows that as a group, approximately 50% of the lakes showed no change in trophic state parameters, 40% showed an increase and 10% showed a decrease. According to trophic state theory discussed above, when the primary limiting nutrient (phosphorus) increases, then chlorophyll should increase and Secchi depth should decrease. For consistency in the trend analyses, if phosphorus significantly increases then so should chlorophyll, while Secchi depth should significantly decrease. However, examining the trend analysis results for Method 1 shows that only two lakes (Big Red Fish and Campbell) followed this trophic state pattern and for Method 2 only one lake (Campbell) followed the trophic state theory (Table 10A through 10D). This is very unusual and strongly suggests that other environmental parameters are impacting lake trophic status assessments and erroneous trophic classifications could occur over time. However, this finding is consistent with the dynamic nature of the dune lakes discussed earlier in Issue 2: Outlet Management. The plots in Figure 8 have also already shown that color and not chlorophyll is the primary factor determining Secchi depth in the dune lakes.

Table 10A. Summary of analyses to determine seasonality and trends for total phosphorus in Walton County's coastal dune lakes using the two different methods described previously in the text.

	Total Phosphorus (µg/L)		
Lake	Seasonal Analysis	Method 1	Method 2
Allen	Seasonality	Significant Increase	Significant Increase
Alligator	Seasonality	No Change	No Change
Big Red Fish	Seasonality	Significant Increase	Significant Increase
Camp Creek	Seasonality	Significant Increase	Significant Increase
Campbell	No Seasonality	Significant Increase	Significant Increase
Deer	Seasonality	Significant Decrease	Significant Decrease
Draper	No Seasonality	No Change	No Change
Eastern	Seasonality	Significant Increase	Significant Increase
Eastern North	Seasonality	No Change	No Change
Fuller	No Seasonality	No Change	No Change
Grayton	No Seasonality	No Change	No Change
Little Red Fish	Seasonality	Significant Increase	Significant Increase
Morris	No Seasonality	Significant Decrease	Significant Decrease
Oyster	No Seasonality	No Change	No Change
Powell	Seasonality	Significant Increase	Significant Increase
Stallworth	Seasonality	Significant Increase	Significant Increase
Stewart	N/A	N/A	N/A
Western	No Seasonality	No Change	No Change
Western Northeast	Seasonality	Significant Increase	Significant Increase

Table 10B. Summary of analyses to determine seasonality and trends for total nitrogen in Walton County's coastal dune lakes using the two different methods described previously in the text.

	Total Nitrogen (µg/L)		
Lake	Seasonal Analysis	Method 1	Method 2
Allen	No Seasonality	Significant Increase	Significant Increase
Alligator	No Seasonality	No Change	No Change
Big Red Fish	Seasonality	Significant Increase	Significant Increase
Camp Creek	No Seasonality	No Change	No Change
Campbell	No Seasonality	Significant Increase	Significant Increase
Deer	Seasonality	No Change	No Change
Draper	No Seasonality	No Change	No Change
Eastern	No Seasonality	Significant Increase	Significant Increase
Eastern North	No Seasonality	No Change	No Change
Fuller	No Seasonality	Significant Decrease	Significant Decrease
Grayton	No Seasonality	No Change	No Change
Little Red Fish	Seasonality	No Change	No Change
Morris	No Seasonality	No Change	No Change
Oyster	No Seasonality	No Change	No Change
Powell	No Seasonality	No Change	No Change
Stallworth	No Seasonality	Significant Increase	Significant Increase
Stewart	N/A	N/A	N/A
Western	No Seasonality	No Change	No Change
Western Northeast	No Seasonality	Significant Increase	Significant Increase

Table 10C. Summary of analyses to determine seasonality and trends for chlorophyll concentrations in Walton County's coastal dune lakes using the two different methods described previously in the text.

	Chlorophyll (µg/L)		
Lake	Seasonal Analysis	Method 1	Method 2
Allen	Seasonality	Significant Increase	Significant Increase
Alligator	Seasonality	No Change	No Change
Big Red Fish	Seasonality	Significant Increase	No Change
Camp Creek	Seasonality	No Change	No Change
Campbell	No Seasonality	Significant Increase	Significant Increase
Deer	Seasonality	Significant Decrease	Significant Decrease
Draper	No Seasonality	No Change	No Change
Eastern	No Seasonality	Significant Increase	Significant Increase
Eastern North	No Seasonality	No Change	No Change
Fuller	No Seasonality	Significant Increase	Significant Increase
Grayton	No Seasonality	No Change	No Change
Little Red Fish	No Seasonality	Significant Increase	Significant Increase
Morris	No Seasonality	No Change	No Change
Oyster	No Seasonality	Significant Increase	Significant Increase
Powell	No Seasonality	No Change	No Change
Stallworth	No Seasonality	Significant Increase	Significant Increase
Stewart	N/A	N/A	N/A
Western	Seasonality	No Change	No Change
Western Northeast	No Seasonality	Significant Increase	No Change

Table 10D. Summary of analyses to determine seasonality and trends for Secchi depth measurements in Walton County's coastal dune lakes using the two different methods described previously in the text.

	Secchi Depth		
Lake	Seasonal Analysis	Method 1	Method 2
Allen	No Seasonality	No Change	No Change
Alligator	No Seasonality	No Change	No Change
Big Red Fish	No Seasonality	Significant Decrease	No Change
Camp Creek	No Seasonality	No Change	No Change
Campbell	No Seasonality	Significant Decrease	Significant Decrease
Deer	No Seasonality	No Change	No Change
Draper	No Seasonality	Significant Increase	Significant Increase
Eastern	No Seasonality	No Change	No Change
Eastern North	No Seasonality	Significant Increase	Significant Increase
Fuller	No Seasonality	Significant Increase	Significant Increase
Grayton	No Seasonality	No Change	No Change
Little Red Fish	No Seasonality	Significant Increase	Significant Increase
Morris	No Seasonality	Significant Increase	Significant Increase
Oyster	No Seasonality	Significant Increase	Significant Increase
Powell	No Seasonality	Significant Increase	Significant Increase
Stallworth	No Seasonality	Significant Decrease	Significant Decrease
Stewart	N/A	N/A	N/A
Western	No Seasonality	No Change	No Change
Western Northeast	No Seasonality	No Change	No Change

To further examine this variability in the trophic state of Walton County's coastal dune lakes, the Coefficient of Variation was calculated for each trophic state parameter for the whole period of record using the following equation:

CV=(SD/X)*100

Where CV is the coefficient of variation as a percentage, SD is the standard deviation (not the Secchi Disc!) of the data, and X is the mean of the data.

This coefficient is often used to compare the relative variability of samples. Therefore, to compare Walton County's coastal dune lakes to other Florida lakes, the coefficient of variation was also calculated for 1,437 lakes from 49 counties using Florida LAKEWATCH data. These data clearly show that the variability in trophic state data of Walton County's coastal dune lakes is much higher than that in other Florida lakes (Table 11). This is consistent with the dynamic nature of the dune lakes as described earlier in Issue 2: Outlet Management. The implications of these findings are that the background variability defined by Terrell et al. 2000 are probably too small and not appropriate for determining trends in the coastal dune lakes and that it is much more difficult to really show a significant trend for these lakes using any statistical analyses. Even though Tables 10A through 10D show some significant trends, it is unlikely that these trends are real, considering the large variability in trophic state data collected from the coastal dune lakes. It will take more long-term data to really determine if the dune lakes are actually changing.

There is one notable exception to the above-mentioned statement. In 1980, Canfield (1981) sampled two of Walton County's coastal dune lakes (Western Lake and Oyster Lake) on three separate dates. In 1980 the total phosphorus, total nitrogen, chlorophyll, and Secchi depth measured in Western Lake were not significantly different from the current Florida LAKEWATCH data, suggesting as mentioned above that the dune lakes are variable but not really changing (Tables 7A through Table 7D). However, Oyster Lake's total phosphorus concentration showed a significant increase, from an average of 34 µg/L in 1980 to an average of 82 µg/L in current LAKEWATCH data (2001 to 2007). Total nitrogen and chlorophyll in Oyster Lake also increased, but not as dramatically as total phosphorus, while Secchi depth remained approximately the same. The causes of these increases are currently unknown and may only be determined by further comprehensive investigation/sampling. Walton County has initiated a multi-phased restoration project on this lake. The isolated wetlands located on the northeast and northwest sides of the lake are being re-connected to the lake. Oyster Lake's outfall has to cross underneath CR 30A and was fixed at the wrong elevation after a hurricane. Walton County is in the midst of trying to remove the box culvert and reset the outfall at the appropriate elevation. CBA and LAKEWATCH are evaluating the water chemistry, soil composition, and plant community before and after construction.

Table 11. Comparison of the mean coefficient of variations (CV %) for trophic state parameters calculated using data from Walton County's coastal dune lakes and other Florida LAKEWATCH lakes (1,437 lakes from 49 Florida Counties) averaged by county.

		LAKEWATCH Lakes (49 Counties)		
Parameter	Average Dune Lakes CV %	Mean CV %	Minimum CV %	Maximum CV %
Total Phosphorus (µg/L)	46	36	17	57
Total Nitrogen (µg/L)	37	27	15	38
Chlorophyll (µg/L)	89	71	32	120
Secchi Depth (m)	37	29	19	46

Salinity

The process of how salinity changes in Walton County's coastal dune lakes has already been discussed in Issue 2: Outlet Management. It is important to remember that conditions have to be just right for saltwater from the Gulf to enter a coastal dune lake. The outlet of a coastal dune lake has to open deep enough for the hydraulic gradient to be low enough that a high tide will bring saltwater into the lake (see Figure 6). Thus, a lake can "open" many times before conditions are "just right" for water to flow from the Gulf into the lake. Storm surges are also capable of bringing saltwater into the dune lakes, but researchers have estimated these to occur on the order of centuries.

CBA volunteers have been collecting salinity data at the surface and bottom of each coastal dune lake for various lengths of time. Salinity at the surface averages 5.3 ppt across all the coastal dune lakes sampled, with Lake Allen having the lowest mean surface salinity of 0.1 ppt and Lake Powell having the highest mean surface salinity of 16.8 ppt (Table 12A). Bottom salinity for all the dune lakes averages 8.0 ppt, with Lake Allen having the lowest mean bottom salinity of 0.1 ppt and the Grayton section of Western Lake having the highest mean bottom salinity concentration of 19.0 ppt (Table 12B).

Salinity concentrations can be extremely variable, not only among Walton County's coastal dune lakes but also within each dune lake. Within one lake, Eastern Lake, surface salinity between December 2001 and June 2008 has ranged from 2.0 ppt to 30.4 ppt (Table 12) and the salinity in Eastern Lake showed a recent decrease of surface salinity from 15.7 ppt in September 2005 to 1.9 in February 2008 (Figure 9). This decreasing salinity was a concern for many stakeholders during the Phase I citizen meetings. However, as discussed earlier in Issue 2: Outlet Management, South Walton County received a tremendous amount of rainfall in February and March of 2008, just after the phase I citizen meetings. As a result, most of the dune lake outfalls opened up, including Eastern Lake. During these openings, channels became deep enough that many lakes received water from the Gulf, and lakes that were experiencing decreased salinity concentrations experienced an exchange of water with the Gulf of Mexico causing increases in salinity. For example, Eastern Lake surface salinity increased from 1.9 ppt in February 2008 (the month of the Phase I meeting) to 6.0 ppt in May of 2008 (Figure 9). Bottom salinity in Eastern Lake increased from 1.85 ppt in January 2008 to 21.9 ppt in March 2008. This again shows that the water chemistry of the dune lakes is dynamic and driven to a large extent by mechanisms already discussed in the Outlet Management Section.

Table 12. Mean (average), minimum and maximum salinity concentrations at the surface (A) and at the bottom (B) measured by CBA volunteers in Walton County's coastal dune lakes for the period of record and number of sampling days listed.

Table 12A

Lake	Start Date	Last Record	Number of Samples	Surface Salinity (ppt) Mean	Minimum	Maximum
Allen	2/10/03	5/14/08	46	0.1	0.0	0.5
Alligator	2/10/03	5/26/08	52	1.8	0.0	11.1
Big Red Fish	3/29/02	5/31/08	65	6.3	0.2	26.9
Camp Creek	3/18/02	4/19/08	53	3.3	0.0	23.5
Campbell	5/3/02	5/1/08	60	0.1	0.1	0.1
Deer	12/13/01	5/30/08	50	0.3	0.0	3.3
Draper	2/25/03	6/10/08	53	9.4	0.9	24.6
Eastern	12/20/01	5/23/08	69	11.4	2.0	30.4
Eastern North	4/18/03	5/8/08	55	10.1	1.4	29.4
Fuller	4/3/02	5/14/08	52	0.3	0.1	1.6
Grayton	6/11/02	6/1/08	69	12.0	2.1	27.9
Little Red Fish	3/13/02	5/26/08	56	4.4	0.0	21.3
Morris	6/20/02	5/1/08	60	1.9	0.1	5.3
Oyster	2/2/02	5/23/08	51	1.8	0.1	6.4
Powell	8/8/02	5/18/08	58	16.8	7.5	27.2
Stallworth	3/22/02	5/19/08	62	2.9	0.1	13.8
Western	5/18/02	6/10/08	59	6.5	1.6	16.4
Western Northeast	5/18/02	3/29/08	55	5.9	0.5	15.2

Table 12B

Lake	Start Date	Last Record	Number of Samples	Bottom Salinity (ppt)		
				Mean	Minimum	Maximum
Allen	2/10/03	5/14/08	46	0.1	0.0	0.5
Alligator	2/10/03	5/26/08	52	8.6	0.0	26.4
Big Red Fish	3/29/02	5/31/08	65	11.8	0.2	29.7
Camp Creek	3/18/02	4/19/08	53	12.9	0.0	30.1
Campbell	5/3/02	5/1/08	60	0.5	0.1	28.5
Deer	12/13/01	5/30/08	50	0.2	0.0	0.9
Draper	2/25/03	6/10/08	53	13.2	1.9	29.7
Eastern	12/20/01	6/18/08	69	14.6	1.9	32.3
Eastern North	4/18/03	5/8/08	55	12.7	1.6	30.7
Fuller	4/3/02	5/14/08	52	0.4	0.1	1.8
Grayton	6/11/02	6/1/08	69	19.0	3.7	32.7
Little Red Fish	3/13/02	5/26/08	56	4.6	0.0	18.3
Morris	6/20/02	5/1/08	60	2.9	0.1	16.3
Oyster	2/2/02	5/23/08	51	2.0	0.1	6.7
Powell	8/8/02	5/18/08	58	18.4	11.6	31.0
Stallworth	3/22/02	5/19/08	62	5.0	0.1	16.3
Western	5/18/02	6/10/08	59	11.5	2.7	36.4
Western Northeast	5/18/02	3/29/08	55	9.1	1.6	28.8

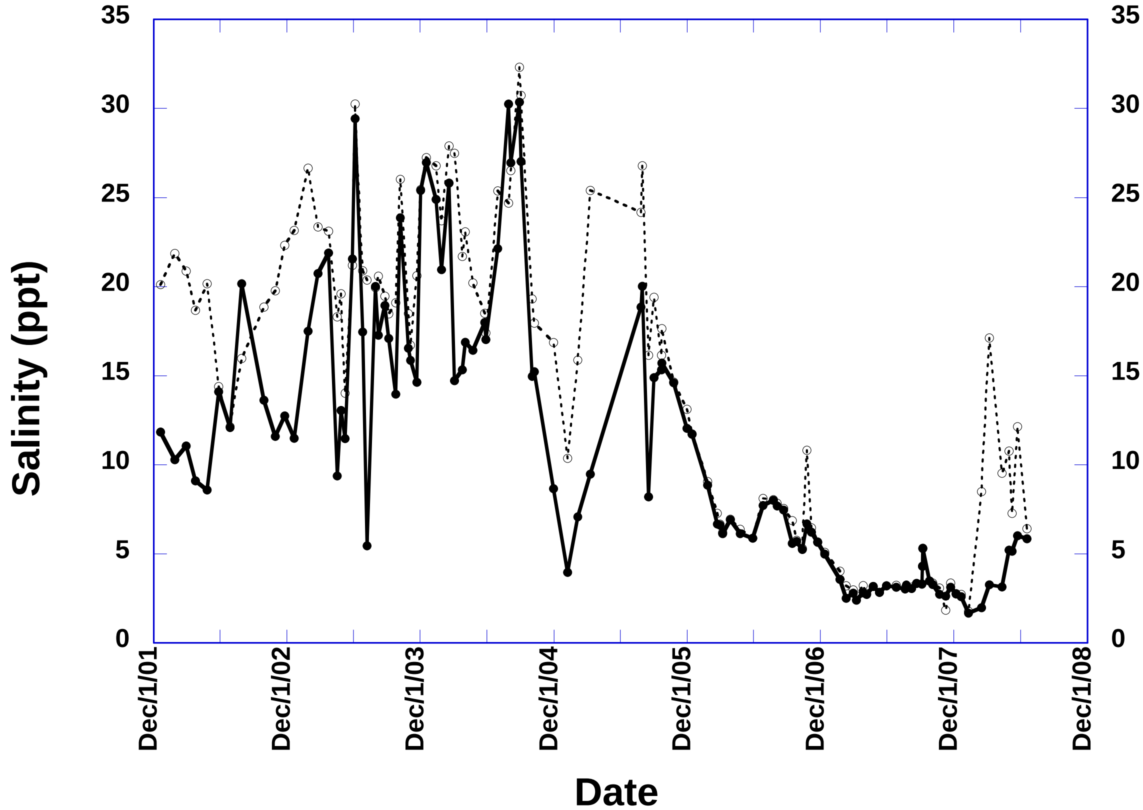


Figure 9. Surface (solid line) and bottom (dashed line) salinity concentrations (ppt: parts per thousand) in Eastern Lake from December 2001 to June 2008 sampled by CBA volunteers.

When saltwater enters a dune lake and changes the salinity, the whole ecology of flora and fauna can be affected. There are organisms adapted to only fresh water (salinity less than 2 ppt), brackish water (salinity ranging from 2 to 18 ppt) or saltwater environments (salinity greater than 18 ppt). Remane and Schlieper (1971) wrote an excellent detailed description of how salinity impacts flora and fauna of aquatic systems. Their treatise on salinity is extremely detailed and well beyond the scope of this document, but for those individuals interested, it is an extremely comprehensive document.

The primary issue for this report, as voiced by stakeholders in the early issues meetings is whether the salinity in the dune lakes is high enough to maintain saltwater species of fish and other organisms of concern, which include but are not limited to: spotted seatrout (*Cynosion nebulosus*), red drum (*Scianenops ocellata*), gulf flounder (*Paralichthys albigutta*) and blue crab

(*Callinectes sapidus*). Many of these organisms can survive and flourish in a wide range of salinities from fresh to extremely brackish water. However, these organisms cannot reproduce in the mostly freshwater habitats of the coastal dune lakes. Therefore, the presence and abundance of these organisms is dependent on emigration from the Gulf into the lake via an opening large enough for passage (outlet of the lake). Thus, the frequency and duration of the outlet openings, which are determined by many factors (see Issue 2: Outlet Management), ultimately will determine the presence and/or abundance of saltwater "critters" within individual dune lakes, regardless of the salinity.

In July 2007, the Florida Fish and Wildlife Conservation Commission (FFWCC) conducted a limited fish survey in Oyster Lake and Stallworth Lake, using experimental gill nets and seines. Eleven fish species were captured in Stallworth Lake, but only five fish species were captured in Oyster Lake (Table 13). Oyster Lake has obstructions (three box culverts and two culverts) to fish passage from the Gulf to the lake. These obstructions may be the primary reason why only one primarily saltwater fish species was captured in Oyster Lake. Stallworth Lake has a more natural fluctuating outlet, which is more conducive to fish movement from the Gulf to the lake, and nine primarily saltwater fish species were captured in the lake. Both lakes have a separation distance of about 300 ft and a sweep distance of about 400 ft and at the time of fish sampling both lakes had salinities of less than 2.5 ppt, suggesting that the difference in presence of saltwater species is, therefore, most likely due to access for fish to move from the Gulf into the lake. Concern about the presence and abundance of saltwater organisms in the dune lakes, therefore, probably should focus more on optimal outlet opening frequency and less on salinity!

Table 13. Species list of fish caught using experimental gillnets and seines by FFWCC personnel in Oyster Lake and Stallworth Lake during July 2007.

Fish Species	Oyster Lake	Stallworth Lake
Freshwater Fish		
Largemouth bass (*Micropterus salmoides*)	X	
Bluegill (*Lepomis macrochirus*)	X	
Redear sunfish (*Lepomis microlophus*)	X	
Eastern Mosquitofish (*Gambusia affinis*)	X	X
Sailfin molly (*Poecilia latipinna*)	X	X
Saltwater Fish		
Striped mullet (*Mugil cephalus*)	X	X
Sheephead minnow (*Cyprinodon variegatus*)		X
Gulf killifish (*Fundulus grandis*)		X
Bay anchovy (*Anchoa mitchille*)		X
Red drum (*Sciaenops ocellata*)		X
Silver perch (*Bairdiella chrysura*)		X
Gulf flounder (*Paralichthys albigutta*)		X
Pinfish (*Lagodon rhomboide*)		X
Gray snapper (*Lutjanus griseus*)		X

Bacteria and other possible chemical contamination

There are many possible sources of bacterial contamination in Florida lakes, but the sources can be grouped into three broad categories: human waste contamination, domestic animal waste contamination, and natural sources of contamination (i.e., aquatic birds). The disposal of untreated human waste into the nearest water body, which was once a common practice, is no longer practiced or condoned. There are also legal requirements for the treatment of wastes. In the highly developed areas of Florida, large municipal wastewater treatment plants usually provide treatment. Small package plants and septic tanks are generally used in rural areas.

The detection of human pathogens (bacteria and viruses) in water is extremely difficult. Attempts to do so are extremely costly and time-consuming and are also seldom successful. Therefore, nearly all bacterial monitoring programs use certain groups of non-disease causing (nonpathogenic) bacteria as indicator organisms of fecal contamination. If the indicator organisms are present in a water sample, it is traditionally assumed that disease-causing bacteria may be present. Historically, agencies charged with insuring public health have used two groups of bacteria to detect fecal contamination - the total coliform and fecal coliform bacterial groups.

The coliform group consists of several major types (genera) of bacteria belonging to a family that the professionals call the Enterobacteriaceae. Bacteria have historically been assigned to the coliform group based on the ability of scientists to detect lactose fermentation (the production of gas). Based on this definition, all aerobic and facultative anaerobic, gram-negative, nonspore-forming, rod-shaped bacteria were included in the coliform group. Total coliform counts are obtained after incubating the water sample for 48 hours at 35°C. Fecal coliforms are then separated from total coliforms by incubating samples at 44.5°C for 24 hours. Regardless of the seemingly complex definition for the coliform group of bacteria, the total and fecal coliform groups were chosen at the time because they were the only tests readily available and the measurements were easy to make. Their use continues in the 21st century, not only because of the ease of measurement, but also because the tests are relatively inexpensive.

When many cities and towns were still contaminating water with untreated waste discharges, the total and fecal coliform tests were an extremely important detection tool, and problems with the tests were not considered important. The vast majority of cities and towns have now constructed wastewater treatment plants to eliminate the major health threats associated with bacterial contamination. Due to shortcomings of the older total and fecal coliform tests, there were demands to establish new criteria before using a group of bacteria as an indicator of fecal contamination. While new tests are used to evaluate drinking water, agencies continue to use total and fecal coliforms tests to determine the safety of water for recreation.

As noted earlier, it was assumed by many agencies that the detection of coliforms meant that recent fecal contamination was present and that a health threat could be posed by the possible presence of pathogens. Many state governments, including Florida's, enacted legislation establishing numerical coliform counts as criteria for determining the safety of water for drinking and recreation. However, as the major sources of fecal contamination were corrected, the use of total coliforms became problematic. Total coliforms are a natural part of the bacterial community (microfauna) of plants. When there is no major source of contamination, the bacteria originating from plants can dominate and provide elevated total coliform counts. The presence of total coliforms, therefore, cannot always be used to indicate the possible presence of pathogens. Their presence may only be indicative of plant material in the water.

The fecal coliform bacteria test is the more reliable indicator of fecal contamination. Use of this test, however, has been based on the assumptions that fecal coliforms are only from warm-blooded animals and that fecal coliforms do not survive in water for an extended period of time. When dealing with massive human contamination from untreated wastes or from an inoperative wastewater plant, these assumptions are typically good. Unfortunately, the assumptions have become dogma among many public health workers. Studies of fecal coliform bacterial tests have shown that non-harmful bacteria can yield false positive results with the standard tests. The studies have also definitively shown that fecal coliforms can survive and even multiply in the natural environment. Perhaps even more important is the fact that the fecal coliform counts do not correlate with the incidence of gastrointestinal illness in recreational waters.

Florida, like many other states, has established numerical criteria for fecal and total coliform contamination in fresh waters classified as Class III waters (Florida Department of Environmental Protection: Chapter 62-302.530, Florida Administrative Code). Class III water is defined as water designated for the purpose of recreation and the propagation and maintenance of a healthy, well-balanced population of fish and wildlife.

In Florida, the fecal coliform standard is:

MPN or MF counts shall not exceed a monthly average of 200, nor exceed 400 in 10% of the samples, nor exceed 800 on any one day. Monthly averages shall be expressed as geometric means based on 10 samples taken over a 30-day period.

The total coliform standard is:

Less than or equal to 1000 as a monthly average; nor exceed 1,000 in more than 20% of the samples examined during any month; less than 2,400 at any time. Monthly averages shall be expressed as geometric means based on a minimum of 10 samples taken over a 30-day period using either the MPN or MF counts.

MPN represents the "most probable number" of bacteria per 100 mL of water sample and MF represents the number of bacterial colonies counted on a membrane filter per 100 mL. As with any bacterial indicator, it is impossible to guarantee with 100% certainty that some individual will not become ill upon contact with water. However, if the number of total coliform and fecal coliform colonies isolated from a water sample is below the state-established criteria, there is a very strong probability that the water is safe for recreation!

There is limited data on total and fecal coliform bacteria in Walton County's coastal dune lakes. Florida LAKEWATCH, however, sampled four dune lakes (Big Redfish, Campbell, Deer and Eastern) in 2000 and CBA sampled seven dune lakes (Allen, Campbell, Deer, Fuller, Morris, Oyster and Stallworth) for total coliform bacteria and *Escherichia coli* (*E. coli*) in 2006-07. *E.*

coli is one species of fecal coliform that can be used as a specific indicator of human, domestic and natural sources of fecal contamination (McLellan and Jensen 2003). When *E. coli* counts are used instead of fecal coliform counts, the chance of false positives (e.g. *Klebsiella sp*.) counted as fecal coliforms is reduced (Shireman and Cichra 1994). *E. coli* counts are also better indicators of fecal pollution than fecal coliform counts, because some types of fecal coliform bacteria may replicate in the environment and falsely elevate the estimate of fecal contamination (McLellan et al. 2001). The use of *E. coli* as an indicator of fecal contamination is recommended by the United States Environmental Protection Agency (U.S. EPA) based on studies demonstrating a direct relationship between the density of *E. coli* organisms in water and the occurrence of swimming-associated gastroenteritis (U.S. EPA 1986).

The limited counts taken on one day show that total coliforms exceeded the state standards in all four lakes sampled by LAKEWATCH and in four of the seven lakes (Fuller, Stallworth, Allen and Oyster) sampled by CBA (Table 14). It is highly possible that many of the total coliforms could be false positives like *Klebsiella sp,* because the more important *E. Coli* numbers were all well below the state standards for fecal coliforms except for Lake Allen. Similarly, an examination of *E. coli* in 99 Florida lakes showed that 98% of the lakes were all well below the state standards, suggesting that there is limited evidence of widespread fecal contamination in Florida lakes. However, the coastal dune lakes counts were only from ten lakes taken on one day in July by LAKEWATCH and on four days in December, January and February by CBA, and Hoyer et al. (2006) show a strong seasonal effect on *E. coli* counts. Therefore, in order to be certain there is no current problem with bacterial contamination of the dune lakes, additional sampling would have to be accomplished.

Table 14. Mean, minimum, and maximum counts of *Escherichia coli* (*E. coli*) and total coliforms collected by Florida LAKEWATCH July 26, 2000 from four Walton County dune lakes and by CBA on four dates: December 1, 2006 (Allen and Oyster Lakes), February 20, 2007 (Campbell and Morris Lakes), December 7, 2006 (Deer and Fuller Lakes), and January 10, 2007 (Stallworth Lake). Lakes in bold exceeded State standards for that sampling date.

			E. coli Coliforms (colonies per 100 ml)			
Data Collectors	Lake	Samples	Mean	Minimum	Maximum	% of samples above 400
CBA	**Allen**	**7**	**110**	**10**	**550**	**14**
LAKEWATCH	Big Red Fish	12	22	0	70	0
CBA	Campbell	8	11	0	50	0
LAKEWATCH	Camp Creek	12	42	0	400	0
CBA	Deer	8	16	0	40	0
LAKEWATCH	Deer	12	8	0	100	0
LAKEWATCH	Eastern	13	0	0	0	
CBA	Fuller	8	62	0	300	0
CBA	Morris	6	17	0	100	0
CBA	Oyster	8	138	0	300	0
CBA	Stallworth	8	18	10	30	0

		Total Coliforms (colonies per 100ml)				
		Samples	Mean	Minimum	Maximum	% of samples above 1,000
CBA	**Allen**	**7**	**14240**	**6250**	**18710**	**100**
LAKEWATCH	**Big Red Fish**	**12**	**915**	**520**	**1360**	**50**
CBA	Campbell	8	43	20	90	0
LAKEWATCH	**Camp Creek**	**12**	**2117**	**700**	**5900**	**59**
CBA	Deer	8	319	180	840	0
LAKEWATCH	**Deer**	**12**	**908**	**600**	**1700**	**25**
LAKEWATCH	**Eastern**	**13**	**1992**	**400**	**10400**	**31**
CBA	**Fuller**	**8**	**2363**	**900**	**5800**	**88**
CBA	Morris	6	717	200	1700	17
CBA	**Oyster**	**8**	**4838**	**3100**	**6900**	**100**
CBA	**Stallworth**	**8**	**4880**	**2210**	**7020**	**100**

Many stakeholders were also concerned about the possible contamination of fish with heavy metals and other chemicals. Unfortunately, there is no available information on the concentrations of heavy metals and other chemicals in the fish populations inhabiting Walton County's coastal dune lakes. Therefore, if this is truly a concern, then efforts should be made to appropriate funds to examine this possibility.

Summary of Potential Management Options for Issue 3: Water Quality

Option 1: Maintain current citizen water quality monitoring program conducted by Florida LAKEWATCH and CBA to monitor long-term nutrient concentrations, chlorophyll levels, water clarity and other basic water chemistry parameters. Additionally, find volunteers to begin sampling identified dune lakes that are currently not being sampled by Florida LAKEWATCH (Stewart, Horseshoe, Tresca and Little Deer Lake).

Justification:

Nutrient enrichment of lakes has been a major concern in Florida since at least 1960. Stakeholders around Walton County's coastal dune lakes have also shown considerable concern about the potential eutrophication of the dune lakes. However, analysis of the existing water quality data indicates that there has been no significant enrichment of most dune lakes to date and that the nutrient concentrations are at levels that would be expected from the geology in which the dune lakes exist. Thus, nutrient enrichment is not the water quality problem that many individuals believed it was. However, it is prudent to continue existing nutrient-related water quality monitoring to insure (the citizens insurance policy) that a problem does not arise in the future.

Approach:

Florida LAKEWATCH is the State of Florida's volunteer citizen lake monitoring program (Chapter 91-69; s 240.5329, F.S.). The program is designed to work with citizens who collect monthly water samples, which are analyzed for total phosphorus, total nitrogen and chlorophyll concentrations. The citizens also measure water clarity by use of a Secchi disc. Citizens in Walton County participate simultaneously in a local program coordinated through the Choctawhatchee Basin Alliance (CBA) of Okaloosa-Walton College. Citizens measure and record other basic water chemistry parameters by use of a "hydrolab" instrument. Currently, citizens around Walton County's coastal dune lakes with the assistance of CBA are monitoring the water in all but two of Walton County's coastal dune lakes that were identified by the Walton County Dune Lakes Advisory Board. Thus, there is now a monitoring system in place to detect any potential adverse effects of additional nutrient inputs.

Florida LAKEWATCH is operated by the University of Florida and is funded by several sources interested in protecting Florida's water resources including the Florida Department of Environmental Protection's Water Quality Assurance Trust Fund. With this funding support and the continued efforts of citizen volunteers, Florida LAKEWATCH should be able to continue the existing nutrient-related monitoring in the long-term. The only caveat to consider is that LAKEWATCH requires an annual appropriation from the Florida Legislature for operation, and expenses continue to rise while budgets continue to decrease. LAKEWATCH has minimized its operational costs for the program in this area by partnering with CBA. CBA is locally coordinating many aspects of the LAKEWATCH program in Walton County. CBA should be able to continue to coordinate existing nutrient-related monitoring in the long-term for both Florida LAKEWATCH and the additional water quality sampling provided by CBA, as long as CBA continues to be receive its funding for its Coastal Dune Lake Program from Walton County.

One nutrient-related issue that still seems to be of concern to some citizens is lawn fertilization. The available water quality evidence clearly indicates that lawn fertilization is not a problem on Walton County's coastal dune lakes. However, if the concern persists for some, the individual(s) must understand that the nutrient of concern for the dune lakes is phosphorus (Table 9). The fertilizer industry has recently developed specially formulated blends that contain slow-release nitrogen (the nutrient responsible for keeping grass green) and contain no phosphorus. Availability of these new blends is limited in Florida, so the user will have to pay more to purchase the phosphorus-free fertilizers.

Option 2: Because Oyster Lake was the only coastal dune lake showing a definitive increase in nutrient concentration, increase the sampling effort on Oyster Lake to determine where nutrient enrichment is originating.

Justification:

Nutrient enrichment of lakes has been a major concern in Florida since at least 1960. Stakeholders around Walton County's coastal dune lakes have also shown considerable concern about the potential eutrophication of the dune lakes. However, analysis of the existing water quality data indicates there has been no significant enrichment in all dune lakes to date except for Oyster Lake, which has shown a significant nutrient increase since 1981. Thus, additional sampling will be required to determine the source of this nutrient enrichment for future restoration/management activities.

Approach:

Florida LAKEWATCH is the State of Florida's volunteer citizen lake monitoring program (Chapter 91-69; s 240.5329, F.S.). The program is designed to work with citizens who collect monthly water sample which are analyzed for total phosphorus, total nitrogen and chlorophyll concentrations. The citizens also measure water clarity by use of a Secchi Disc. Citizens around Oyster Lake, with the assistance of CBA, have been monitoring the water of Oyster Lake regularly since October of 2001. Thus, there is currently a monitoring system in place that can be expanded to increase sampling efforts at Oyster Lake.

All sources of water input to the lake should be identified, and water samples should be taken from them monthly along with regular lake sampling. Additional samples from water inputs should also be taken immediately after any significant rainfall to catch nutrient concentrations entering the lake. Water discharge at all identified water inputs should be measured using a flow meter and cross sectional area of the water inputs. If this option is selected, LAKEWATCH and/or CBA personnel could aid in setting up sampling stations and protocols. This extra sampling effort will also help to develop a nutrient budget for Oyster Lake. Utilizing the expertise of CBA and Florida LAKEWATCH offers the citizens concerned about Oyster Lake an efficient, cost-effective platform for investigating Oyster Lake's potential problems as well as potential problems facing the other dune lakes.

Option 3: Initiate a comprehensive total and fecal coliform bacteria-scan monitoring program to determine if Walton County's coastal dune lakes are being contaminated by fecal material from urban/residential development. If high bacteria counts are found, do further tests to determine if high counts are due to false positives (natural occurrences).

Justification:

The Walton County coastal dune lakes stakeholders participating in the TEAM Approach showed great concern for the possible effects of bacterial contamination in the dune lakes. Limited research on four of the lakes has not detected any biological contamination that threatens human health, but concerns continue to persist because of potential bacterial contamination from poorly functioning septic tanks and/or storm water. Therefore, initiating a low-cost monitoring program could go a long way toward alleviating lake users' concerns and alerting lake users of any impending problem. It has also been proven elsewhere in the State of Florida that fixing the "real" problem (i.e., correcting one damaged septic tank) is far cheaper than fixing a "perceived" problem (i.e., constructing a central collection system and requiring everyone to connect).

Approach:

Limited financial support for bacteriological monitoring on Walton County's coastal dune lakes should be sought. It is possible that Walton County could get the public health office to conduct the study depending on the availability of funds. Total and fecal coliform tests taken by this office would provide legally defensible information if the County needed to close any lake to public use. Alternatively, Florida LAKEWATCH and/or CBA could provide assistance, but their results have no legal standing authority for closing a lake; the bacterial results could only be used as a way of scanning for potential problems. However, there are tests available that can be used by volunteers. If a suitable volunteer monitoring program can be developed, the citizens using

Walton County's coastal dune lakes could monitor the lake more frequently and more intensely by themselves. After evaluating the results of two studies, one by Florida LAKEWATCH and one from CBA, monitoring should initially be limited to every other month, sampling total and fecal coliforms at 10 stations per lake.

If Walton County or another entity should initiate a bacterial monitoring program, attention should be directed toward determining if any high fecal coliform counts are due to false positives before the lake is closed for human use. Bacteria from the genus *Klebsiella*, a natural soil bourne bacterium, can cause abnormally high fecal coliform counts. The other potential source that needs to be considered is aquatic birds roosting near the lake. Aquatic birds have been identified as a major source of contamination on other lakes, but birds represent a natural source over which humans have little control.

Option 4: Initiate a comprehensive chemical, heavy metal and/or pesticide-monitoring program to determine if Walton County dune lakes are being contaminated by watershed development and/or initiate a chemical scanning of the fish population to determine if fish are safe to eat.

Justification:

The Walton County coastal dune lakes stakeholders participating in the TEAM Approach were concerned by the possible effects of chemical, heavy metals and/or pesticide contamination on the dune lakes. There is no current information available on chemical, heavy metals and/or pesticide concentrations in Walton County's coastal dune lakes. However, there is also no current evidence that chemical, heavy metal and/or pesticide contamination is impacting aquatic organisms in Walton County's coastal dune lakes.

Approach:

The cost of monitoring water chemistry in Walton County's coastal dune lakes with CBA and the Florida LAKEWATCH program is minimal, as long as volunteers continue to donate their time. Therefore, no additional funds are needed to continue this monitoring program. However, this program only addresses lake trophic state variables.

Another program would have to be started in order to monitor chemical, heavy metal and/or pesticidal contaminants. This would require the appropriation of new funds, probably lots of dollars. Some commonly measured constituents found in storm water runoff and wastewater that potentially could occur in surface waters include: surfactants (alkylbenzenesulfonate), toxic organic compounds (1,4-dichlorobenzene, toluene, xylenes, 1,1-dichloroethane, 1,1,1-trichloroethane, and acetone) and metals (antimony, arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver and zinc). The cost of analyzing these constituents varies considerably among laboratories. The cost of analyzing surfactants is about $35 to $65 per sample, toxic organic compounds around $90 to $125 per compound, and metals about $15 to $25 per sample. These figures do not account for the time and personnel used to collect the samples. So, it is easy to see how costs soar.

The sampling design (location and frequency) in Walton County's coastal dune lakes would have to be considered carefully before starting such a program. Currently, CBA and Florida LAKEWATCH sample sixty (60) stations monthly in Walton County's coastal dune lakes. Assuming the same number of samples (504) would be collected for additional chemical analysis, it would cost approximately $400,000 dollars to analyze each of the above variables for one year. Additional money would be needed for sample collection and data analyses.

If concerns remain and costs are an issue, the focus should then be on contamination of fish (or any other organism living in the dune lakes that may be eaten by humans). Biological organisms can accumulate contaminants in their flesh. If measured levels are below established food consumption guidelines, there most likely is not a serious environmental contamination problem. Analyzing tissue is not cheap, but far less expensive than general contaminant monitoring programs. Such testing also directly addresses one major concern – Is it safe to eat?

Issue 4: Watershed/Inlet Management

As previously mentioned, lake trophic status and general water chemistry in lakes throughout the world are determined primarily by the geology, soils, hydrology, vegetation, and the climate of the area where a lake exists. Using this information and measured water chemistry, Griffith et al. (1997) defined 47 lake regions in Florida, which are described in a final report, *Lake Regions of Florida*, published by the U.S. EPA (EPA/R97/127). The Walton County dune lakes belong to the Gulf Coast Lowlands lake region. The geology in this lake region is dominated by sand dunes and well-sorted fine sand of the Pleistocene and the lakes lie in the Coastal Strip divisions of the Apalachicola Delta District. Lakes in this geology and lake region are most often classified as oligotrophic to mesotrophic.

For individual lakes, trophic status and general water chemistry are the direct result of their location within a landscape and the nutrients and sediment that enter them from their watershed. A watershed is defined as the area from which water flows into a lake. Drawing a line that connects the highest points around a water body is one way to delineate a watershed. A more accurate delineation would also include areas that are drained into a lake through underground pathways. In Florida, these may include drainage pipes or other man made systems, seepage from high water tables and possibly flow from springs. Any activities within individual watersheds, regardless of whether they are natural or man-made, can affect the characteristics of a lake. For this reason, managing the watershed and discreet inlets to Walton County’s coastal dune lakes was an important issue to the stakeholders at the original issues meetings.

From discussions with stakeholders at the last issues meeting, the primary concern for the watershed issue was the fear that development in the watershed is causing nutrient enrichment and eutrophication of the dune lakes. Fortunately, Walton County has already established a Coastal Dune Lake Protection Zone under the Walton County Land Development Code. This protection zone considers the following items for the protection of the dune lakes: 1) septic tank placement, 2) storm water management, 3) erosion control, 4) hazardous waste, 5) seawalls and bulkheads, 6) endangered species, 7) point and non-point sources of pollution, 8) preserving open space, and 9) construction restriction near dune lake outlets. These same protection concerns are also elaborated in the Walton County Comprehensive Plan, adding to the protection of Walton County's coastal dune lakes.

The Land Development Code seems to be working because, with the exception of Oyster Lake, there is no strong evidence that the trophic state of Walton County's coastal dune lakes has significantly increased over the last decade (see Issue 3: Water Quality / Trophic State). As previously mentioned, additional research will be needed to determine the cause of the increased nutrient concentrations in Oyster Lake. However, the water quality analyses are not definitive evidence that there are not problem areas in the dune lake watersheds that could potentially change the water chemistry of the lakes.

In January 2000, the Walton County Board of County Commissioners retained Hartman and Associates to develop a storm water management plan for Walton County (Hartman and Associates 2001). The elements of this plan include: watershed delineation, existing infrastructure inventory, level-of-service evaluation, water quality evaluation, water quantity evaluation, floodplain evaluation, capital improvement project prioritization, alternate analysis for retrofit improvements, public education, funding alternatives and other related topics. Hartman and Associate's (2001) first task was to complete a field survey with the County Commissioner's respective road foremen, to develop an initial county problem list. When finished, this list consisted of approximately 250 sites, some of which were located in the watersheds of the dune lakes. This report is almost 10 years old and much growth and development has occurred since then, suggesting that there may be additional problem areas in the watersheds of the dune lakes. These problem areas hold the potential of causing water quality problems and should be examined with that in mind.

Summary of Potential Management Options for Issue 4: Watershed/Inlet Management

Option 1: "Do Nothing" to change current watershed management.

Justification:

With the exception of Oyster Lake there is no strong evidence that the trophic state of Walton County's coastal dune lakes has significantly increased over the last decade (see Issue 3: Water Quality / Trophic State). This is also the decade of the fastest population growth and urban development in Walton County, suggesting that the current Walton County Land Development Code is maintaining the current lake trophic status of the coastal dune lakes.

Approach:

Strictly enforce the current Walton County Land Development Codes and follow the recommendations put forth in the Walton County Comprehensive Plan to help maintain the current status of Walton County's coastal dune lakes.

Option 2: Examine Walton County's coastal dune lakes watershed problems identified by Hartman and Associates (2001) to see if they still present a potential problem to the water quality of the dune lakes. Additionally, because the report is almost 10 years old, and tremendous population growth and urban development have occurred during that ten years, identify other potential sources of storm water pollution. Identified problems should be prioritized and cost-effective solutions should be found to repair or replace problem situations.

Justification:

Population growth and urban development in a watershed have the potential to increase nutrient loading to lake systems. Well-designed developments (according to proper codes) have much less potential to increase nutrient loading to lake systems. Therefore, any identified potential storm water problems should be identified and prioritized for replacement or repair. This is a proactive approach to maintaining the current water quality of Walton County's coastal dune lakes.

Approach:

Personnel from Walton County Public Works should be charged with examining storm water problems identified by Hartman and Associates (2001) that occur in watersheds of Walton County's coastal dune lakes. These personnel should also do field reconnaissance on all dune lakes watersheds identifying other potential storm water problems. Once all potential problems are identified, they should be prioritized and monies should be appropriated to repair the problems in decreasing order of most potential impact to the lake systems.

Issue 5: Aquatic Plant Management

Different species of aquatic plants live in different "worlds" made up of different combinations of sediment, water, and air. Most aquatic plants are secondarily adapted to life in the water, having once lived on land and gradually evolving mechanisms to deal with a watery world. The most important environmental factors affecting the abundance and distribution of aquatic macrophytes in lakes include: light availability, lake trophic state characteristics as they relate to water chemistry, sediment characteristics, wind energy, lake morphology (e.g., surface area, shape, depth etc.), watershed characteristics and others (Florida LAKEWATCH 2007). All of these factors can work independently and/or in combination to determine the species composition, distribution and abundance of aquatic plants in lakes.

A full description of aquatic plant ecology is beyond the scope of this document, but for those interested, see “A Beginners Guide to Water Management, Aquatic Plants in Florida Lakes, Information Circular 111” (Florida LAKEWATCH 2007). All of the previously mentioned factors contribute in part to the distribution and abundance of aquatic plants in Walton County’s coastal dune lakes, but light availability and salinity are probably the two dominant factors that influence the abundance of aquatic plants in the dune lakes.

Aquatic plants require light for growth, thus light availability is often considered the single most crucial environmental factor regulating the distribution and abundance of aquatic plants. Light availability is directly linked to water clarity and as water depth increases or water clarity decreases both the amount and the spectral quality of light for photosynthesis at the lake bottom diminishes. Generally, submersed macrophytes will grow to a depth where at least 10% of the ambient surface light is available. This depth can roughly be estimated by multiplying the Secchi depth (depth at which a black and white disk lowered into a lake disappears) by 1.7. Thus, lakes with the majority of their bottom exceeding 1.7 times the Secchi depth will have fewer aquatic submersed macrophytes.

The importance of light to aquatic plants is evident in recent work by Florida LAKEWATCH graduate students and staff who defined the relationship between maximum depth of aquatic plant colonization and Secchi depth for 279 Florida lakes (Figure 10, Caffrey et al. 2007). This relationship was shown to be similar to those that have been published using data from other parts of the country and world, suggesting that this relationship is extremely robust and can be use to help determine aquatic plant management strategies for lakes. In fact, Florida LAKEWATCH staff (Hoyer et al. 2005) successfully used published relationships between maximum depth of aquatic plant colonization and Secchi depth to estimate changes in the potential aquatic plant coverage of some Florida lakes that have large fluctuations in water level.

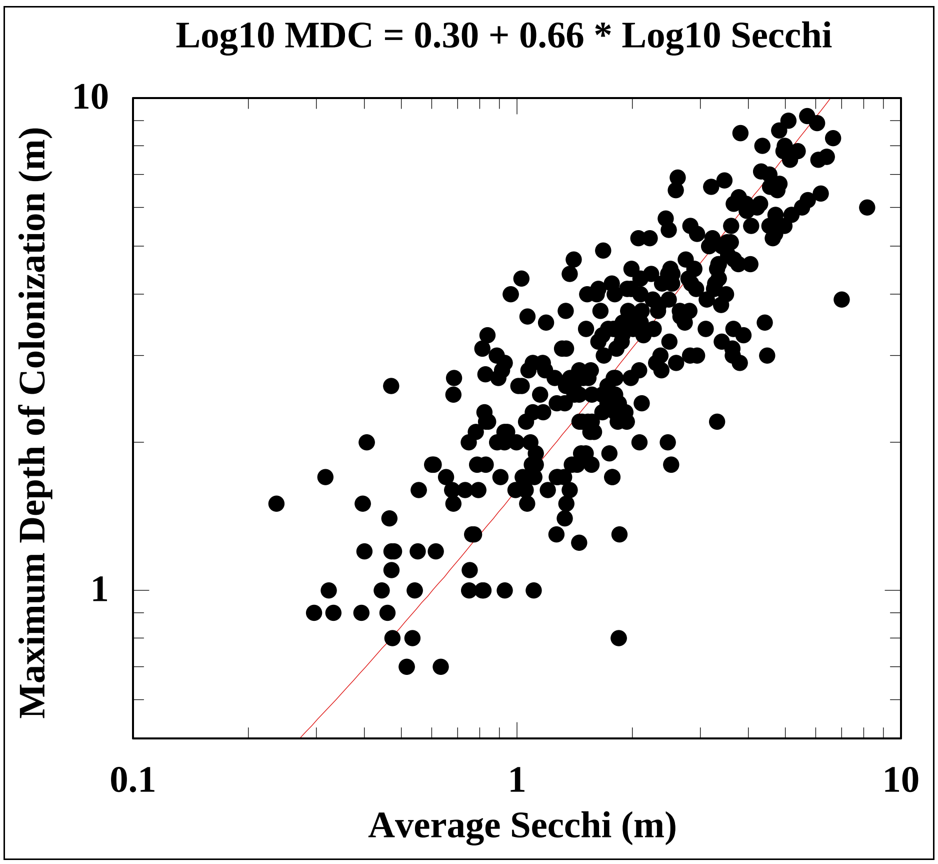


Figure 10. Relationship between maximum depth of aquatic plant colonization and Secchi depth for 279 Florida lakes (From Caffrey et al. 2007).

While Walton County's coastal dune lakes are not turbid, they are extremely colored, and Figure 8 shows that color primarily determines the water clarity of the coastal dune lakes. Therefore, when lakes are extremely colored, the light available for aquatic plant growth is less, thereby limiting the abundance of aquatic plants. When rainfall is low and the color of the dune lakes is less, then there is more available light, increasing the potential for the growth of aquatic plants. Generally, lakes with color values greater than about 50 to 100 Pt-Co units have little or no submersed aquatic plants (Bachmann et al. 2002). Color in the Walton County dune lakes is generally above 50 Pt-CO units, and plant surveys in seven different Walton County dune lakes between 2000 and 2007 (Florida LAKEWATCH, Appendix VIII) showed very few submersed aquatic plants.

As previously mentioned (Issue 3: Water Quality / Salinity), when saltwater enters a dune lake and changes the salinity, the whole ecology of flora and fauna can be affected. There are organisms adapted to only fresh water (salinity less than 2 ppt), brackish water (salinity ranging from 2 to 18 ppt) and some adapted to only saltwater environments (salinity greater than 18 ppt). This generalization holds true for aquatic plants, as Hoyer et al. (2004) showed by examining aquatic plants in five low-lying coastal rivers of Florida. During drought situations when saltwater moved up the rivers, freshwater submersed plants (e.g., Tapegrass *Vallisneria americana*) disappeared and more saltwater tolerant species like widgeon grass (*Ruppia maritima*) began to appear. Similarly, submersed aquatic plant biomass in Eastern Lake in 2000 averaged 0.4 kg wet wt/m^2 when the lake was highly colored and 2.9 kg wet wt/m^2 in 2007 when the lake had less color (Appendix VIII). Because Eastern Lake still maintained salinities above 3 ppt in 2007, the submersed plant biomass was primarily widgeon grass (*Ruppia maritma*), which is a saltwater tolerant plant. Therefore, over time the species composition, abundance and distribution of aquatic plants in Walton County's coastal dune lakes will fluctuate according to yearly changes in the water clarity and salinity within the individual lakes.

Regarding aquatic plants, one of the primary issues of concern voiced by the stakeholders in the first issues meetings was the fear of exotic aquatic plants invading Walton County's coastal dune lakes. Not all of Walton County's coastal dune lakes have been surveyed for aquatic plant species composition, distribution and abundance. However, Florida LAKEWATCH surveyed seven dune lakes for aquatic plants (Appendix VIII), and indeed all seven had populations of the exotic species torpedograss (*Panicum repens)*. Oyster Lake had two exotic species, torpedograss and Alligator weed (*Alternanthera philoxeroides*). Florida Department of Environmental Protection personnel also surveyed aquatic plants present in Western lake during 1991 and found torpedograss, suggesting that this exotic plant has been present in the dune lakes for some time. However, no submersed (e.g., Hydrilla *Hydrilla verticillata)* or floating (e.g., water hyacinth *Eichhornia crassipes*) exotic aquatic plants were identified in either plant survey.

CBA, as part of its Coastal Dune Lakes Program, is working with local volunteers to map each of the dune lakes for exotic and invasive species identified by the Florida Department of Environmental Protections Bureau of Aquatic and Invasive Plants. Once a lake is mapped, a regional biologist from the Bureau will develop a management plan for that lake. CBA will work with its community partners to find grants and funding to implement the management plan. Currently, CBA has mapped Eastern, Western, Oyster, Big Red Fish, Camp Creek, Alligator, and Little Redfish. The Bureau biologist is working on a management plan for Oyster Lake. Funding was received to remove invasive and exotic species on Oyster Lake and replant with native plants. Grants were recently written by CBA for the other lakes mapped and CBA has plans to start mapping additional lakes in the fall.

Summary of Potential Management Options for Issue 5: Aquatic Plant Management

Option 1: "Do Nothing" to manage aquatic plants in Walton county's coastal dune lakes.

Justification:

Currently few exotic aquatic plants have been identified in the seven lakes that have been surveyed for plants by Florida LAKEWATCH. Additionally, the species composition, abundance and distribution of aquatic plants in the Walton County dune lakes fluctuate with changes in water color and salinity of the dune lakes. These two water chemistry parameters fluctuate naturally and are related primarily to rainfall inputs to the lakes (see Issue 3: Water Quality / Lake Trophic Status).

Approach:

Allow the aquatic plants in Walton County's coastal dune lakes to fluctuate naturally.

Option 2: Initiate a bi-annual (once every two years) aquatic plant survey to monitor the changes in the aquatic plant communities of the Walton County dune lakes, continually looking for invasions from new exotic aquatic plants and changes in established populations of exotic plants (primarily torpedograss).

Justification:

While the general aquatic plant community fluctuates naturally in Walton County's coastal dune lakes, there is always the possibility of invasions from exotic aquatic plants. It takes constant monitoring to guard against invasions from new exotic aquatic plant species. Torpedograss is present in most if not all of Walton County's coastal dune lakes and is currently not presenting extreme problems. However, torpedograss has the growth ability to create huge monocultures inhibiting many lake uses. Therefore, monitoring an expanse of torpedograss through time would send a red flag for the control and/or management of this plant.

Approach:

Florida LAKEWATCH uses an aquatic plant sampling procedure that can be used to quickly and easily determine the species composition, abundance and distribution of aquatic plants in lake systems. If funding could be found to use this procedure every year or every other year, the aquatic plant communities in Walton County's coastal dune lakes could be monitored and any changes occurring due to other than natural environmental conditions could be detected. If new exotic aquatic plants are found or torpedograss populations expand causing problems, then maintenance control programs like those used elsewhere in Florida could be initiated.

Option 3: Establish a maintenance control program for torpedograss with proper herbicides and begin revegetation efforts with native plants.

Justification:

Many invasive aquatic plants can cause problems, including but not limited to impairing lake access and displacing native aquatic plants and associated wildlife. Torpedograss is an exotic invasive plant that was identified in all of Walton County's coastal dune lakes that were surveyed for aquatic plants (seven lakes) and would be a good candidate for a maintenance control approach.

Maintenance control (or management) refers to controlling plants when they exist at low levels and doing it before the plants reach a problem level. It has been defined in a Florida Statute as follows:

> ....a maintenance program is a method for the control of non-indigenous aquatic plants in which control techniques are utilized in a coordinated manner on a continuous basis in order to maintain the plant population at the lowest feasible level as determined by the department [Department of Natural Resources now Department of Environmental Protection.] F.S. 369.22

Maintenance control of aquatic weeds (both native and non-native) reduces the detrimental environmental effects caused by the weeds and reduces the potential for environmental impacts from aquatic plant control activities. Maintenance control offers the following advantages:

1. Detrimental impacts of aquatic non-indigenous weeds on native plant populations are reduced.
2. Detrimental impacts of aquatic weeds on water quality are reduced.
3. The amount of organic matter deposited on the lake bottom from natural processes is reduced.
4. The amount of organic matter deposited on the lake bottom after control of aquatic plants is reduced.
5. Less herbicide and therefore less money is used in the long term.

A problem experienced when conducting a maintenance control program is that people do not perceive a weed problem and question the need to spray. Therefore, public education is an important part of a successful maintenance control program. Maintenance management is the most environmentally sound method for managing invasive non-native plants. For example, unmanaged water hyacinth can double every 7 - 10 days. Ten plants under the right environmental conditions can grow to cover one acre in a single growing season, often weighing 200 tons. Therefore, the benefit of controlling those 10 plants early should be obvious.

Approach:

If this option is selected, an aquatic plant biologist with the Florida Department of Environmental Protection should be contacted to discuss the development of an overall aquatic plant management program for Walton County's coastal dune lakes. Questions to be addressed are how many and where the aquatic plants should be controlled and what permits are required. Once the basics are established, the riparian owners should be contacted to determine their preferences.

Control of torpedograss and other invasives should be linked with a major aquascaping program for each lake. The stakeholders participating in the TEAM process were not opposed to aquatic plants as long as they were native plants and were not causing major lake use problems. Planting vegetation like giant bulrush (*Scirpus californicus*), duck-potato (*Sagittaria lancifolia*), slender spikerush (*Eleocharis baldwinii*), maidencane (*Panicum hemitomon*), sawgrass (*Cladium jamaicense*) and others in selected locations to enhance plant diversity, but not interfere with lake use was a desired option. Selecting desirable plants and planting them in areas once dominated by torpedograss will not only reduce future torpedograss growth, but also enhance the aesthetic beauty of the dune lakes. However, success of an aquascaping program will require close coordination with the riparian owners and a clear delineation of total costs and who will pay.

Issue 6: Education

The stakeholders attending the first issues forum all agreed that public education was needed to enhance the management of Walton County's coastal dune lakes. While it is virtually impossible to find anyone who would disagree with the establishment of environmental education programs, effective long-term lake management requires that the lake-users and those charged with implementing the plan receive information from a variety of sources to ensure all sides of an issue are presented.

Education is simply a process of helping individuals or groups develop a knowledge base for making life-long decisions. When the educator or educators present only ideas, facts, and other information to further their cause and deliberately damage an opposing cause, the educational material becomes propaganda!

Many of the professionals and stakeholders involved in the initial coastal dune lakes management meetings agreed on the need for environmental education, but they had a strong sense that the information they possess and are using to base management decisions on is not being transferred to the general public. It was felt that this lack of communication was the cause of many conflicts. The professionals agreed that all forms of educational transfer should be used to help fill the information gap between agencies and the public. The information transfer should also be proactive, trying to educate to prevent problems, rather than in response to problems.

There was also a consensus that communication among agencies was lacking and there is a need for a forum where all the management issues for Walton County's coastal dune lakes can be discussed proactively. Fortunately, the Walton County Board of County Commissioners has already set up the Walton County Dune Lakes Advisory Board for that very purpose. Nearly everyone also emphasized that any educational program must be a continuous effort, because the riparian owners living on Walton County's coastal dune lakes are constantly changing, and new owners continually need to be updated on why certain past decisions were made. But, the professionals agreed the citizens should control how they would like to be educated, as this may help the educational material stay with the affected individuals longer.

Summary of Potential Management Options for Issue 6: Education

Option 1: The "Do Nothing Recommendation."

Justification:

Again, this option is always a viable option, but it is probably a less viable option at this time because of the effort spent to develop a comprehensive management plan for Walton County's coastal dune lakes. It is clear that communication -- or the lack of communication -- has been a problem in years past as different activities were initiated around the lakes. If the lake management plan is to truly be a living document, future riparian owners need to be informed of the "whys" that supported initiated lake management activities and where uncertainties exist.

Approach:

Do nothing, but the CDLAB should utilize the educational opportunities that already exist to try to remedy existing deficiencies. Great local resources are CBA and Okaloosa-Walton College.

Option 2: If the CDLAB creates a TAG (technical advisory group), this group should immediately be charged with planning and assisting the CDLAB with implementing a comprehensive community education program for the coastal dune lakes. By incorporating programs that already exist and adding programs in areas where stakeholders are not receiving information pertinent to the preservation and management of the dune lakes, the TAG under the direction of the CDLAB could enhance the educational program for the coastal dune lakes at a minimal cost.

Justification:

The Walton County Dune Lakes Advisory Board with its technical advisory group (chaired by the CBA representative) should guide a community education program for the dune lakes. These two groups, the CDLAB and CBA, having been strongly involved with the development of management plans for the lakes in varying capacities, will maintain sufficient interest in implementing agreed upon recommendations. Over time these two groups will have the ability to insure the plan is a “living” document and that changes to the plan can be made in a timely manner when the facts dictate. These groups are also in an excellent position to identify riparian owner concerns and reach out to existing community education programs to provide the information needed to make cost-effective management decisions. Together these groups are positioned to take advantage of educational resources already available through local and state governmental agencies as well as educational institutions.

Approach:

There is already considerable lake management information available that could be coalesced into a complete coastal dune lakes management educational program produced by CBA, Walton County and others. Additionally, the Northwest Florida Water Management District, the Florida Department of Environmental Protection, and the Florida Fish and Wildlife Conservation Commission represent important sources of educational outreach material and professional insight into real or perceived problems. Florida LAKEWATCH has many information circulars that can also be used to educate people on all aspects of lake management. All of the resources could be assembled by the TAG under the direction of the CDLAB in a very short time. While this team is working, a first step for the Walton County coastal dune lakes stakeholders would be for the working group to give each riparian land owner a copy of this report to show them the major issues of concern and basic information on how coastal dune lakes function.

Issue 7: Fish and Wildlife

As previously mentioned, the primary fish and wildlife issue for this report is whether the salinity in the dune lakes is high enough to maintain saltwater species of fish and other organisms of concern. These organisms of concern include but are not limited to spotted seatrout (*Cynosion nebulosus*), red drum (*Scianenops ocellata*), gulf flounder (*Paralichthys albigutta*) and blue crab (*Callinectes sapidus*). These organisms can survive and flourish in a wide range of salinities from fresh to extremely brackish water. However, these organisms cannot reproduce in the mostly freshwater habitats of the dune lakes, so the presence and abundance of these organisms is dependent on emigration from the Gulf into the lakes via an opening large enough for passage (outlet of the lake). Thus, the frequency and duration of the outlet openings, which are determined by many factors (see Section 2 Outlet Management), ultimately will determine the presence and/or abundance of saltwater "critters" within individual dune lakes regardless of the salinity.

Unfortunately, no group or agency routinely monitors the fish populations living in the Walton County dune lakes. However, the Florida Fish and Wildlife Conservation Commission (FFWCC) in July 2007 conducted a short fish survey in Oyster Lake and Stallworth Lake, using experimental gill nets and seines. Eleven fish species were captured in Stallworth Lake, but only five fish species were caught in Oyster Lake (Table 13). Oyster Lake has obstructions to fish passage from the Gulf to the lake in the form of three box culverts and two driveway culverts. Thus, only one primarily saltwater fish species was captured in Oyster Lake. Stallworth Lake has a more natural fluctuating outlet, which is more conducive to fish movement from the Gulf to the lake. Nine saltwater fish species were captured in Stallworth Lake. Both lakes have a separation distance of about 300 ft and a sweep distance of about 400 ft and at the time of fish sampling both lakes had salinities of less than 2.5 ppt, suggesting that the difference in presence of saltwater species is due to access for fish to move from the Gulf into the lakes. Therefore, if the concern about the presence and abundance of saltwater organisms in the dune lakes remains in the future, citizen attention should focus more on the frequency of outlet openings and potential blockages rather than salinity.

The above example shows clearly how routinely monitoring fish populations could yield information on how interfering with dune lake outlets and watersheds may potentially be impacting fish and wildlife populations in the Walton County dune lakes, especially if fish passage is blocked.

Table 13 (repeated). Species list of fish caught using experimental gillnets and seines by FFWCC personnel in Oyster Lake and Stallworth Lake during July 2007.

Fish Species	Oyster Lake	Stallworth Lake
Freshwater Fish		
Largemouth bass (*Micropterus salmoides*)	X	
Bluegill (*Lepomis macrochirus*)	X	
Redear sunfish (*Lepomis microlophus*)	X	
Eastern Mosquitofish (*Gambusia affinis*)	X	X
Sailfin molly (*Poecilia latipinna*)	X	X
Saltwater Fish		
Striped mullet (*Mugil cephalus*)	X	X
Sheephead minnow (*Cyprinodon variegatus*)		X
Gulf killifish (*Fundulus grandis*)		X
Bay anchovy (*Anchoa mitchille*)		X
Red drum (*Sciaenops ocellata*)		X
Silver perch (*Bairdiella chrysura*)		X
Gulf flounder (*Paralichthys albigutta*)		X
Pinfish (*Lagodon rhomboide*)		X
Gray snapper (*Lutjanus griseus*)		X

Summary of Potential Management Options for Issue 7: Fish and Wildlife

Option 1: Initiate a monitoring program for the fish communities using Walton County's coastal dune lakes.

Justification:

The status of Walton County dune lake's fish communities are often the focal point of stakeholders' concerns regarding the overall quality of the dune lakes. Unfortunately, professionals from state agencies, because of cost factors, do not routinely monitor fish communities in small lakes like Walton County's coastal dune lakes. Without information on the status of the fish populations, it will be impossible to determine if a problem truly exists that needs to be addressed. Conducting assessments over the long-term would provide the Walton County Dune Lakes Advisory Board with a quantitative basis for assessing various lake management decisions relative to the fish communities.

Approach:

Funds should be sought to monitor the fish communities in Walton County's coastal dune lakes. FFWCC, academic institutions, or private consulting firms could complete sampling. The fish communities of Walton County's coastal dune lakes should be assessed in the spring using electrofishing, seining and gillnet equipment. With the fisheries information that would be obtained by single day sampling events, the status of the dune lakes' fish communities could routinely be compared for year-to-year trends. The data could also be compared with similar data from other Florida lakes of similar size and productivity to better determine if the lakes are functioning naturally.

Option 2: Remove obstructions to fish passage at Oyster Lake and monitor the return of saltwater species.

Justification:

Oyster Lake has fewer saltwater species residing in the lake than expected, and there are known obstructions to fish passage. Oyster Lake could therefore become a test case for assessing the role of blockages (originating due to development) upon dune lake fauna.

Approach:

CDLAB should approach Public Works to ascertain what would be needed to clear a passage to Oyster Lake and what the projected cost would be. Once a plan is developed, funding sources should be sought, recognizing this type of endeavor might be an excellent opportunity for agencies to partner. If a partnership can be developed, the cost to a single group might not be so onerous in difficult financial times. FFWCC might also be able to bring some federal dollars to bear, because fish passage in the nation’s waters is a national concern.

Literature Cited

Bachmann, R. W., C. A. Horsburgh, M. V. Hoyer, L. K. Mataraza and D. E. Canfield, Jr. 2002. Relations between trophic state indicators and plant biomass in Florida Lakes. Hydrobiologia 470: 219-234.

Browder, A. E., and R. G. Dean. 1998. Preliminary investigation of the characteristics of coastal lake outlets in the Florida Panhandle. Hurricane opal beach recovery study: Task C. Report. Florida Department of Environmental Protection, Bureau of Beaches and Coastal System. Tallahassee, Florida.

Brown, C. D., D. E. Canfield, Jr., R. W. Bachmann, and M. V. Hoyer. 1998. Seasonal Patterns of chlorophyll, nutrient concentrations and Secchi Disk transparency in Florida Lakes. Lake and Reservoir Management 14:60-76.

Burns, N. M., J. C. Rutherford and J. S. Clayton. 1999. A monitoring and classification system for New Zealand lakes and reservoirs. Lake and Reservoir Management 15:255-271

Caffrey, A. J., M. V. Hoyer, and D. E. Canfield. 2007. Factors affecting the maximum depth of colonization by submersed macrophytes in Florida lakes. Lake and Reservoir Management 23: 287-297.

Canfield, D.E., Jr. 1981. Chemical and trophic state characteristics of Florida lakes in relation to regional geology. Final Report, Florida Cooperative Fish and Wildlife Unit. U.S. Fish and Wildlife Unit. U.S. Fish and Wildlife Service. Gainesville, Florida. 444 p.

Canfield, S. J. and D. E. Canfield, Jr. 1994. The TEAM Approach, "Together for Environmental Assessment and Management": A Process for Developing Effective Lake Management Plans or Water Resource Policy. Lake and Reserv. Manage. 10(2):203-212.

Florida LAKEWATCH. 2001. A beginners guide to water management-Lake Morphology. Information Circular #104. Department of Fisheries and Aquatic Sciences, University of Florida/Institute of Food and Agricultural Sciences. Library, University of Florida. Gainesville, Florida.

Florida LAKEWATCH. 2007. A Beginner's Guide Water Management —Aquatic Plants in Florida (Circular 111). University of Florida/Institute of Food and Agricultural Sciences. October 2007. 47pp.

Forsberg, C. and S. R. Ryding. 1980. Eutrophication parameters and trophic state indices in 30 Swedish waste receiving lakes. Arch. Hydrobiol. 89: 189-207.

Griffith, G. E., D. E. Canfield, Jr., C. A. Horsburgh and J. M. Omernik. 1997. Lake regions of Florida. Report to the Florida Department of Environmental Protection. U. S. Environmental Protection Agency, Corvallis, Oregon.

Hartman and Associates, Inc. 2001. Walton County Stormwater Master Plan. Hartman and Associates, Inc. 12815 Emerald Coast Parkway, Suite 110, Destin, Florida.

Hoyer, M. V., T. K. Frazer, S. K. Notestein and D. E. Canfield, Jr. 2004. Vegetative characteristics of three low-lying Florida coastal rivers in relation to flow, light, salinity and nutrients. Hydrobiologia 528:31-43.

Hoyer, M. V., C. A. Horsburgh, D. E. Canfield, Jr., and R. W. Bachmann. 2005. Lake level and trophic state variables among a population of shallow Florida lakes and within individual lakes. Canadian Journal of Fisheries and Aquatic Sciences. 62: 1-10.

Hoyer M. V., G. D. Israel, and D. E. Canfield, Jr. 2006. Lake User's Perceptions regarding Impacts of Lake Water Level on Aesthetics and recreational Uses. Final Report. Southwest Florida Water Management District, Brooksville, Florida.

Hoyer, M. V. and D. E. Canfield, Jr. 2008. Findings from workshops on citizen's concerns regarding the future management of Walton County coastal dune lakes. Phase I Report. Choctawhatchee Basin Alliance. 18 pgs.

Hoyer, M. V., J. L. Donze, E. J. Schulz, D. J. Willis, and D. E. Canfield, Jr. 2006. Total coliform and Escherichia coli counts in 99 Florida lakes with to some common limnological factors. Lake and Reservoir Management. 22: 141-150.

Lackey, R. T. 2006. Axioms of ecological policy. Fisheries 31(6): 286-290.

Lamb, B.L., and B.A.K. Coughlan. 1993. Legal considerations in inland fisheries management. In: Kohler, C., Hubert, W. Inland Fisheries Management in North America. Bethesda, MD: American Fisheries Society. p. 77-10.

Lambert W. J., P. Aharon, and A. B. Rodrigez. 2008. Catastrophic hurricane history revealed by organic geochemical proxies in coastal lake sediments: a case study of Lake Shelby Alabama (USA). J. Paleolimnology 39: 117-131.

Liu, K. 2007. Uncovering prehistoric hurricane activity. American Scientist 95: 126-133.

Liu, K., and M. L. Fearn. 1993. Lake-sediment record of late Holocene hurricane activities from coastal Alabama. Geology 21: 793-796.

McLellan, S., and E. Jensen. 2003. Lake Michigan beaches: Urban storm water and water quality advisories. Lakeline 23: 27-29

McLellan, S., A. D. Daniels, and A. K. Salmore. 2001. Clonal populations of thermotolerant Enterobacteriaceae in recreational water and their potential interface with fecal Escherichia coli counts. Appl. Environ. Microbiol. 67: 4934-4938.

Nielsen, P. 1992. Coastal bottom boundary layers and sediment transport. World Scientific Press. Singapore.

Remane, A. and C. Schlieper. 1971. Biology of brackish water. Second Revised Edition. Wiley Iterscience Division. John Wiley & Sons, Inc New York.

Sakamoto, M. 1966. Primary production by phytoplankton community in some Japanese lakes and its dependence on lake depth. Arch. Hydrobiol. 62: 1-28.

Shireman, J. V., and C. E. Cichra. 1994. Evaluation of aquaculture effluents. Aquaculture 123: 55-68.

Simon, H. A. 1955. Recent advantages in organization theory. In: S. K. Bailey, et al. Research frontiers in politics and government. Brookings Institution, Washington, DC. p. 247.

Terrell, J. B., D. L. Watson, M. V. Hoyer, M. S. Allen, and D. E. Canfield Jr. 2000. Temporal water chemistry trends (1967-1997) for a population of Florida waterbodies. Lake and Reservoir Management 16:177-194.

United States Environmental Protection Agency. 1986. Ambient water quality criteria for bacteria. EPA 440/5 84/002. Office of Water Regulations and Standards, Criteria and Standards Division. Washington, DC.

Appendix I

Walton County Ordinance 2002-02

Appendix II

Coastal Dune Lakes Advisory Board Manual

Appendix III

Findings From Workshops On Citizens' Concerns Regarding The Future Management of Walton County Coastal Dune Lakes

Appendix IV

Axioms of Ecological Policy

Appendix V

Browder & Dean (1998)

Appendix VI

Water Chemistry Trends in Walton County's Coastal Dune Lakes

Appendix VII

Florida LAKEWATCH Circular 111

Appendix VIII

Aquatic Plant Survey Data for Seven Walton County Dune Lakes