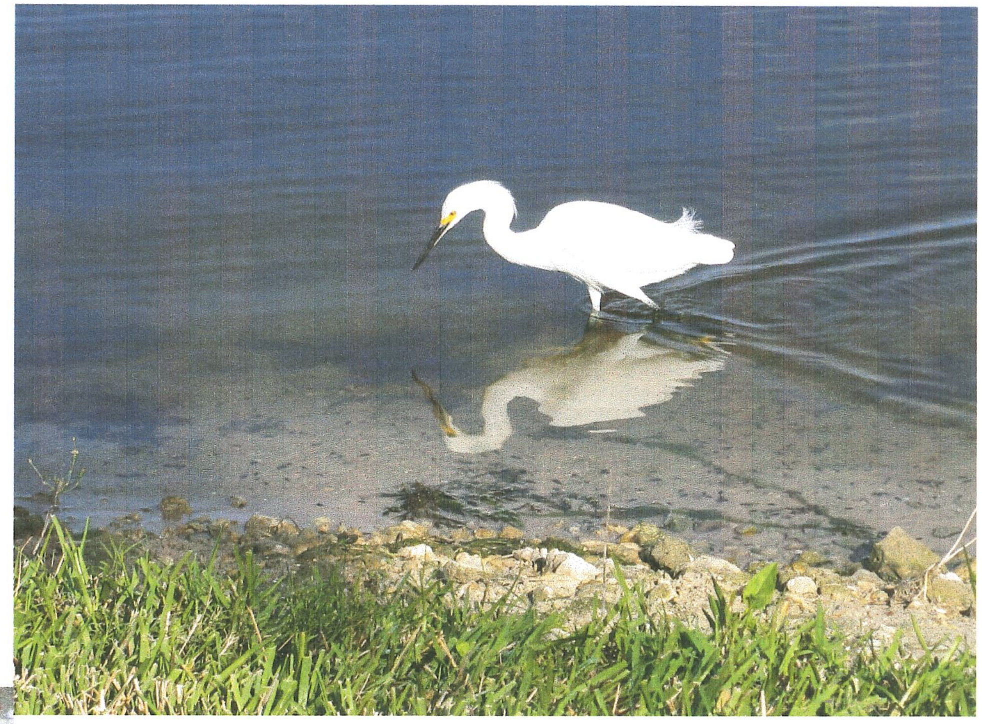
Village Walk lake - North Naples, FL
September 2009
Notice the water clarity.



Village Walk lake - North Naples, FL
September 2010
Notice the water condition.

Recommendations – Frederick Talbott fredtalbott@comcast.net

The following recommendations are designed to:

1. Prevent future harmful fertilizer/nutrient runoff and/or leaching into any and all water bodies in and adjacent to Collier County, FL.
2. Prevent the development of Harmful Algal Blooms (HABs) resulting from fertilizer/nutrient pollution of water bodies (ponds, lakes, streams, canals, estuaries, coastal waters) in and adjacent to Collier County, FL.
3. Prevent harmful human and/or animal health impacts and harmful water body impacts caused by fertilizer/nutrient pollution and resulting Harmful Algal Blooms. Most at risk: seniors, children, pets, and—due to prolonged exposure—landscape and lake management workers.
4. Prevent harmful economic impacts that will be caused by the continued presence of Harmful Algal Blooms resulting from fertilizer/nutrient water pollution in Collier County. These include but are not limited to reduced home sales and home values, required home sale disclosure form reporting of Harmful Algal Bloom recurrences, tourism, and the reputation of Collier County, Naples, and Southwest Florida.
5. Prevent lawsuits and other actions focusing on those liable for any and all damage(s) or illness(es) caused by fertilizer/nutrient pollution and/or resulting Harmful Algal Blooms. These include but are not limited to health effects (death, illness, exposure and related risks, etc.), home sales impacts, home price reductions, and neighborhood lifestyle impact and resulting damages (inability to use ponds and lakes, fishing, visual and environmental impacts, etc.). Most at risk for lawsuits: landscaping services and HOAs allowing fertilizer practices that prompt Harmful Algal Blooms.

Recommendations:

_ **Ban the application of fertilizer on lawns and/or turf grass in Collier County from June-September.** This prevents heavy fertilizer runoff and leaching into our ponds, lakes, canals, streams, and estuaries during the rainy season. Suggested $10,000 fine and license revocation for each violation.

_ **Ban any and all heavy "frontloading" of fertilizer to lawns and/or turf grass during the months of April and May.** This practice is rumored to occur—make sure it never happens in Collier County. The practice would reportedly be an attempt to offset the June-September ban. It would likely increase fertilizer pollution in Collier County and adjacent coastal waters. Suggested $10,000 fine and license revocation for each such violation/application.

_ **Ban the use of phosphate or phosphorous (P) fertilizer on turf grass and/or lawn grass in Collier County**. Suggested $10,000 fine and license revocation for each violation.

_ **Ban the application of fertilizer within 15 feet of any water body in Collier County and require the use of deflector fertilizer spreaders with the deflector always positioned on the water side of the spreader when spreading fertilizer.** Suggested $10,000 fine and license revocation for each violation.

_ **Require that all neighborhood storm drains be covered during the application of fertilizer within 15 feet of the storm drain.** This is suggested to prevent the direct entry of fertilizer into the drain and the water body or drain field it leads to. Suggested $100 fine per storm drain per incident.

_ **Establish, limit, and regulate both the amount and frequency of fertilizer applied to lawns and/or turf grass in Collier County**. Suggested $10,000 fine and license revocation for each violation exceeding set limits.

_ **Ban any and all irrigation practices involving the use of pond, lake, canal, stream, or estuary water when there is evidence of a Harmful Algal Bloom in the water.** This prevents aerial spreading of harmful bacteria that may be present in the algae-impacted water. Suggested $10,000 fine and license revocation for each violation/application.

_ **Initiate a study and ongoing monitoring of the immediate, short- and long-term health effects of exposure to Harmful Algal Blooms and water containing bacteria present in Harmful Algal Bloom environments**. Extensive research by the Centers for Disease Control, the Florida Department of Health, and Harmful Algal Bloom researchers in the health and biological sciences have cited reasons for concern. Recognize that Harmful Algal Blooms can severely damage water bodies and impacted ecosystems (fish, amphibians, essential aquatic plants, etc.); they also pose direct health risks to humans and pets. While direct dermal (skin contact) and ingestion (drinking) contact pose certain dangers, aerial ingestion risks resulting from spraying algae contaminated water—by fountains, irrigation methods, and natural wind spray--also poses great risks. Studies have linked some strains of cyanobacteria generated by blue-green algae to catastrophic neurological and other health conditions. Again, most at risk are the elderly, children, pets, and landscape workers who are most frequently and directly exposed to the bacteria.

I suggest contacting the Centers for Disease Control, Environmental Protection Agency, and key medical and biological researchers to request direct assistance in identifying any risks posed by bacteria found in Collier County Harmful Algal Blooms. This is essential, as it is the duty of the county to identify possible or potential health risks here and protect the health and safety of county residents and visitors.

Thank you for considering these recommendations. They should not impact any landscape worker's job opportunities or any landscape company's income. And they may prevent future illness as well as lawsuits or other legal actions against landscape companies and homeowners' associations who could be found to be liable for fertilizer/nutrient pollution and resulting Harmful Algal Bloom impacts. These recommendations are also pro-business. The presence of Harmful Algal Blooms is negatively impacting home sales and home pricing and real estate market recovery. HABs also negatively impact the recovery of the tourism, retirement, and water sports recreational (fishing, boating) sectors. More home sales, tourism, and retirees mean more jobs and a stronger Southwest Florida economy. Please let me know if you would like to discuss these recommendations. Thank you for your consideration.

Frederick Talbott is a resident of Village Walk in Collier County. Village Walk's 82.5 acre lake was impacted by a massive Harmful Algal Bloom from mid-June-October 2010, preventing lake use, devastating lake life (fish, amphibians, shoreline and aquatic vegetation), and directly impacting home sales and values and lakefront habitability. This also raised questions and prompted research regarding the health impacts of living adjacent to and being exposed to prolonged harmful algal blooms and irrigation/aeration using water from the algae infested water body.

Resource Guide for Public Health Response to Harmful Algal Blooms in Florida

Based on Recommendations of the Florida Harmful Algal Bloom Task Force Public Health Technical Panel

G. Meghan Abbott[1*]
Jan H. Landsberg[1]
Andrew R. Reich[2]
Karen A. Steidinger[1,3]
Sharon Ketchen[2]
Carina Blackmore[2]

[1]Florida Fish and Wildlife Conservation Commission
Fish and Wildlife Research Institute
100 Eighth Avenue Southeast
St. Petersburg, Florida 33701 USA

[2]Florida Department of Health
Division of Environmental Health
4052 Bald Cypress Way
Tallahassee, Florida 32399 USA

[3]University of South Florida
Florida Institute of Oceanography
830 First Street South
St. Petersburg, Florida 33701 USA

**Present address follows Acknowledgments*

Florida Fish and Wildlife Conservation Commission
FWRI Technical Report TR-14

2009

of patients, and hospitalizations, but also the time off from work and medical costs incurred by people who experience recurrent symptoms months or years after the initial poisoning.

Economic effects of CFP in the Caribbean are estimated to exceed $10 million (Hoagland *et al.,* 2002). Anderson *et al.* (2000) suggested that a conservative estimate for the economic effects of CFP in the U.S. would average $21.19 million annually (using year 2000 dollars); this estimate included Florida, Hawaii, Puerto Rico, the Virgin Islands, Guam, America Samoa, Northern Mariana Islands, and the economically dependent areas of Marshall Islands, Palau, and Micronesia. In the U.S. and Canada, annual costs for time lost from work and hospitalization expenses are estimated at $20 million (de Sylva, 1994). Because we lack an effective screening procedure, the only reliable method of preventing poisoning is to prohibit sales of fish from known ciguatoxic areas as they do in Tahiti (Bagnis *et al.,* 1990). This prohibition causes significant economic losses to the fishing industry in these regions (de Sylva and Higman, 1980). In Florida, while the sale of barracuda is banned in Miami (Lawrence *et al.,* 1980), the effect on the economy from loss in sales is unknown. Liability for damages due to exposure to toxic fish has fallen on seafood sellers. They have been considered to be responsible for ciguatera transmission even if due care is exercised in preparation and sale of the product (Sturm, 1991). Persons affected have also successfully sued restaurant operators to recover ciguatera-related damages (Nellis and Barnard, 1986).

Existing Monitoring Operations

CFP is a reportable disease in Florida (Chapter 64D-3, Florida Administrative Code). Physicians and other health care professionals in Florida are required to report all cases to the local county health department (CHD). These reports are then entered into Merlin®. State epidemiologists conduct follow-up investigations to confirm these cases. However, the amount of underreporting is estimated to be high, up to 90% of cases (Fleming *et al.,* 1998; McKee *et al.,* 2001).

Outreach attempts have been made to help medical professionals recognize CFP. Use of ciguatera posters in emergency rooms has helped raise the awareness of both physicians and the public and encouraged the reporting of CFP cases. In 1997, a three-month collaborative outreach project by the U of M and the South Florida Poison Information Center (FPIC) resulted in the number of ciguatera cases reported in Dade County increasing 2.7 times over the previous three months (Fleming *et al.,* 1998).

The dinoflagellates that cause CFP are known to occur in Florida waters, but potential ciguateric areas have not been mapped. Fish are not routinely collected to monitor for ciguatoxin; however, there are research initiatives in place (CDC, FDOH, FWC, University of North Carolina at Wilmington) to investigate the distribution of ciguatoxin (and brevetoxin) in fish from known endemic ciguateric areas in the Florida Keys and on the west coast of Florida.

Cyanobacteria (Blue-Green Algae) and Cyanotoxin Poisoning

Background

Florida's diverse freshwater, brackish, and marine environments support a wide variety of cyanobacteria (blue-green algae) blooms. Like other HABs, cyanobacteria can affect water quality, and more importantly, those that produce cyanotoxins can pose a threat to public health. Cyanobacteria can also adversely affect natural resources and the environment. Many of Florida's largest and most important aquatic systems have been affected by persistent cyanobacterial blooms, including Lake Okeechobee; the Harris chain of lakes (Apopka, Griffin, Eustis, and Harris); and the St. Johns, St. Lucie, and Caloosahatchee rivers and their estuaries (Williams *et al.,* 2001, 2006, 2007a; Burns *et al.,* 2002; Phlips *et al.,* 2002; Paerl *et al.,* 2005; Aubel *et al.,* 2006; Burns, 2008).

There are about 20 taxa or species of bloom-forming cyanobacteria that are toxic or potentially toxic in Florida fresh waters, including *Microcystis aeruginosa, Anabaena circinalis, A. flos-aquae, Aphanizomenon flos-aquae, Cylindrospermopsis raciborskii, Oscillatoria* spp., *Lyngbya wollei,* and *Lyngbya* sp. (Chapman and Schelske, 1997; Williams *et al.,* 2001, 2006, 2007a; Phlips *et al.,* 2002; Burns, 2008; Joyner *et al.,* 2008; Yilmaz *et al.,* 2008). (See Appendix E for a table of species and their associated toxins.)

In the United States, Europe, Asia, and Australia, a significant percentage of water samples analyzed for cyanobacteria test positive for cyanotoxins. Because cyanotoxins can be retained in source water, their contamination of drinking-water reservoirs is an important public health concern. The first nationwide drinking water survey in the United States revealed that 80% of 677 samples analyzed (from 45 utility companies) contained microcystins. These are potent hepatotoxins produced by certain species of cyanobacteria (*e.g., Microcystis aeruginosa*); 4% of the positive samples exceeded the World Health Organization's (WHO) safe drinking water guideline of 1µg/L for total microcystin (Carmichael, 2001). In Florida, water-treatment

FWC image

Sampling plants and water in Lake Harris, 2007.

systems have some ability to reduce toxin levels (Drew, 2002). However, it is not known to what extent, if at all, these toxic compounds are making their way through existing treatment processes (Williams *et al.*, 2006). The American Water Works Association (AWWA) is evaluating the effectiveness of various water treatment methods.

Ecology

Unlike the more open marine systems, land-use activities are particularly important factors in stimulating and maintaining cyanobacterial blooms in enclosed freshwater ponds, rivers, and smaller water bodies. Usually found close to urban areas, the highly visible blue-green discolorations caused by cyanobacteria blooms often generate public concern and a demand for attention even in the apparent absence of toxic species.

Anabaena circinalis and *Microcystis aeruginosa* are two of the most widely distributed species in Florida (Williams *et al.*, 2001, 2006; Burns *et al.*, 2002). Being planktonic, they often form extensive surface blooms and scums in eutrophic waters during warm weather and calm winds. Toxic *Anabaena* and *Microcystis* have occurred in lakes Okeechobee and Istokpoga (Carmichael, 1992; Phlips *et al.*, 2002). Elsewhere, *A. circinalis* strains have been reported to produce the neurotoxins anatoxin-a, STX, and neosaxitoxin (Sivonent *et al.*, 1989; Humpage *et al.*, 1994). *Microcystis aeruginosa* strains are known to produce 37 of the 52 microcystins that occur in lakes Okeechobee and Istokpoga (Carmichael, 1992).

Aphanizomenon flos-aquae is also common throughout Florida (Williams *et al.*, 2001, 2006). Anatoxin-a and two neurotoxic alkaloids resembling STX and neosaxitoxin have been isolated from *A. flos-aquae.*

Cylindrospermopsis raciborskii in Florida is known to produce cylindrospermopsin (hepatotoxin) (Burns *et al.*, 2002) and is found principally in tropical and subtropical regions. It forms subsurface blooms and has been reported throughout Florida, including the St. Johns River, Wekiva River, Newnans Lake, Lake Dora, Lake Eustis, Lake Griffin, Lake George, Lake Okeechobee, Lake Wauberg, and Lake Disston, but its distribution appears to be increasing (Chapman and Schelske, 1997; Williams *et al.*, 2001; Phlips *et al.*, 2002). Bloom concentrations of *Cylindrospermopsis* in the hypereutrophic Lake Griffin have been observed to extend over the entire lake for periods in excess of a year (Phlips *et al.*, 2002).

Lyngbya wollei has become increasingly prominent in Florida's freshwater systems. *Lyngbya wollei* has been reported to produce decarbomoylsaxitoxin, decarbomoyl-gonyautoxin, lyngbyawolleitoxin, cylindrospermopsin, and deoxy-cylindrospermopsin in freshwater environments in Australia and the U.S.A. (Carmichael *et al.*, 1997; Seifert *et al.*, 2007). *Lyngbya wollei* has been identified as a complex that probably comprises at least two species (Joyner *et al.*, 2008) that potentially account for observed differences in toxicity reported in Florida. Ongoing sampling and testing may provide additional information on the ecology and toxin production of various freshwater *Lyngbya* species in Florida.

Effects on Human Health

Humans can be exposed to cyanobacteria and their toxins (cyanotoxins) through direct skin contact or by drinking contaminated waters; other possible routes of exposure include inhalation of aerosol, consumption of contaminated food, and even from kidney dialysis using contaminated water (Jochimsen *et al.*, 1998; Pouria *et al.*, 1998; Falconer, 1999, 2005; Chorus *et al.*, 2000). Occupational exposures for fishermen, watermen, and scientists, as well as recreational exposures for the general public, are all possible. However, there are relatively few case reports and even fewer epidemiologic studies of the effects of blue-green algal toxins on human health.

Seasonal gastroenteritis has been reported worldwide and may be related to the consumption of cyanobacterial-toxin-contaminated drinking water or recreational exposures (El Saadi *et al.*, 1995; Fleming and Stephan, 2001). Reports of two cases of pneumonia and 16 other complaints of a variety of gastrointestinal (hepatoenteritis), dermatologic, and respiratory ailments in previously healthy army recruits were likely linked to exposure with a blue-green algal bloom of *Microcystis aeruginosa* (Turner *et al.*, 1990; Fleming and Stephan, 2001; Stewart *et al.*, 2006a).

In Florida, health effects associated with exposure to cyanobacteria are a very important issue (Johnson and Harbison, 2002), but they are not considered to be a reportable disease at this time. It is not possible to estimate the number of Floridians who have been adversely affected by such exposure.

Cyanotoxins belong to one of three groups: neurotoxins, hepatotoxins, and dermatotoxins. Each toxin is defined by the symptoms it produces in animals.

NEUROTOXINS

The cyanotoxic neurotoxins include anatoxin-a, anatoxin-a(s), and STX. STX is also produced by dinoflagellates and is associated with SPFP in Florida's marine systems (Landsberg *et al.*, 2006). Anatoxin-a mimics the neurotransmitter acetylcholine, but the toxin cannot be degraded by the enzyme acetylchoinesterase; anatoxin-a(s) binds to acetylcholinesterase acting as a natural organophosphate; and STXs are sodium-channel blockers (Carmichael, 1992; Fleming and Stephan, 2001). These toxins can cause death within minutes, secondary to effects on respiratory muscles, causing paralysis, convulsions, and suffocation (Carmichael *et al.*, 1979; Fleming and Stephan, 2001; Stewart *et al.*, 2006a).

HEPATOTOXINS

The cyanotoxic hepatotoxins include cylindrospermopsins, nodularins, and microcystins. These toxins damage the liver by altering the cytoskeletal architecture of the hepatocytes (Carmichael, 1994). Cylindrospermopsin is a protein synthesis inhibitor, resulting in widespread necrosis of the tissues in many organs (Terao *et al.*, 1994; Froscio *et al.*, 2003). The nodularins and microcystins are protein phosphatase inhibitors and are potent tumor promoters in animals (Carmichael, 1992; Falconer and Humpage, 1996). Both *in vivo* and *in vitro* studies indicate that both nodularins and microcystins inhibit Type 1 and 2 protein phosphatase activities, which causes the cytoskeletal structure to collapse, thus leading to a loss of liver cell function and eventually cell death (Honkanen *et al.*, 1990, 1991). At lower doses, enteritis and hepatitis are seen shortly after ingestion of microcystins, which at higher doses can cause liver necrosis that leads to death within hours or days (Falconer *et al.*, 1981; Fleming and Stephan, 2001).

Humans exposed to microcystins through contaminated drinking water supplies are also potentially at risk of primary liver cancer (Yu, 1991). An outbreak of human hepatoenteritis was associated with a bloom of *C. racbiorskii* after a domestic drinking-water reservoir became contaminated on Palm Island, northeastern Australia. The majority (139) of cases (148) were in children. The liver was enlarged in all cases, and the initial symptoms resembled hepatitis accompanied by abdominal pain. Kidney malfunction and profuse bloody diarrhea followed. Symptoms occurred after copper sulfate was applied to a dense algal bloom in the water supply (Bourke *et al.*, 1983; Hawkins *et al.*, 1985, 1997).

DERMATOTOXINS

The cyanotoxic dermatotoxins include aplysiatoxins and lyngbyatoxins and are often reported from marine cyanobacterial blooms, including those of *Lyngbya majuscula*. These toxins are potent tumor promoters and protein kinase C activators (Fujiki and Suganuma, 1996). They can cause severe dermatitis with only skin contact and can cause gastrointestinal inflammation if ingested; however, there is no direct evidence for a cause–effect relationship in Florida (WHO, 1999; Fleming and Stephan, 2001). In freshwater, the FDOH Aquatic Toxins Program (ATP) has been investigating reports of skin irritation and rashes from a number of state-owned Florida parks with spring-fed streams. Testing of *L. wollei* found in Florida springs during the summer of 2006 did not detect dermal toxins; however, STX-like compounds were identified by ELISA tests and receptor-binding assay, and the PSP toxins decarbamoylsaxitoxin (dcSTX) and decarbamoylgonyautoxin-2 and -3 (dcGTX-2/3) were identified by HPLC (PBS&J Corporation, 2007; Flewelling, FWC–FWRI, unpublished data).

Elsewhere, there are individual case reports of persons exposed by swimming through blue-green algal blooms, resulting in skin irritation and allergic reactions (both dermatologic and respiratory) with continued sensitivity to skin testing post-exposure (Stewart *et al.*, 2006b). In particular, urticaria (hives), blistering, and even deep desquamation (shedding) of skin in sensitive areas such as the lips and under swim suits have been reported, especially related to contact with *Lyngbya majuscula* from tropical marine areas (Osbourne *et al.*, 2001). Type I hypersensitivity to cyanobacteria (as detected via skin-patch testing and bronchial-provocation testing) has also been reported with exposure to contaminated recreational water (Stewart *et al.*, 2006a).

Effects on Living Resources

Cyanobacterial blooms can kill domestic pets, livestock, and wildlife that drink contaminated surface water as well as aquatic animals that are directly exposed to toxins throughout the water column (Falconer, 2005).

Persistent and decaying blooms, with their accompanying odor, are aesthetically displeasing. However, bloom conditions may create hypoxic (low dissolved oxygen) conditions leading to fish kills and environmental degradation. When the oxygen supply is depleted, oxygen-reliant organisms die, which leads to other cascading environmental problems, including foul odor and the proliferation of undesirable microorganisms. The release of cyanotoxins, a reduction of light availability in the water column, and the alteration or disruption of food webs are also potential effects of cyanobacterial blooms. Large blooms and mats of cyanobacteria can hinder or eliminate the growth of native species and upset the ecological balance by changing the number and type of species present in a given area.

The mat-forming filamentous alga *Lyngbya wollei* can grow to bloom proportions in freshwater littoral zones in Florida, degrading nearshore areas and preventing light from reaching submerged aquatic vegetation (Joyner *et al.*, 2008). An extensive marine *Lyngbya* bloom, primarily comprising *L. confervoides* and *L. polychroa*, on the reef tract offshore of Broward County, Florida, was first noted in 2002. Blooms continue to cause extensive problems as they smother and ultimately kill octocorals and other invertebrates, negatively affecting these reefs (Paul *et al.*, 2005).

Cylindrospermopsis raciborskii has been implicated as a possible cause of the late-1990s mass mortality and reproductive failure of American alligators (*Alligator mississippiensis*) in Lake Griffin in the Oklawaha River system in central Florida. Necropsies of four alligators were inconclusive, but analysis of tissues by ELISA revealed the presence of small quantities of microcystin toxin, a known tumor promoter (Carmichael, 1992; Richey *et al.*, 2001). Other proposed causes include a thiamine (vitamin B1) deficiency in the alligator's diet (Sepulveda *et al.*, 2004). A 2007 *Cylindrospermopsis* bloom occurred with a mallard duck (*Anas platyrhynchos* and mallard hybrids) die-off and led to an intense investigation to determine whether the cause was not a single factor but a multi-factorial association of a number of etiological factors, including cyanotoxins and botulism.

STXs have been detected at low concentrations in blue crabs (*Callinectes sapidus*) surveyed from freshwater and low-salinity areas with chronic cyanobacterial blooms. A study funded by CDC/FDOH to assess levels of microcystins in four species of freshwater fish from each of four lakes has confirmed microcystins in the livers of gizzard shad (*Dorosoma cepedianum*) and bluegill (*Lepomis macrochirus*) (FWC–FWRI, unpublished data). The epiphytic cyanobacterium (family Stigonematales) primarily responsible for avian vacuolar myelinopathy, a neurological disease affecting water birds (Williams *et al.*, 2007b), has been confirmed by PCR for the first time in Florida on several substrate species (Williams *et al.*, 2009).

Economic Effects

Although cyanobacterial blooms cause significant ecological and aesthetic problems and potentially affect the operation of drinking-water facilities, economic costs associated with these blooms in Florida have not been assessed.

Existing Monitoring Operations

Recognizing the need to address cyanobacterial issues in Florida, and following the work conducted under the FHABTF, Florida state agencies have developed an interagency working group to address the response to cyanobacteria bloom events.

Surveys, such as the projects coordinated by the FHABTF (see http://www.floridamarine.org/features/view_article.asp?id=26908), have highlighted the diversity of harmful or toxic cyanobacterial species in Florida (Williams *et al.*, 2001). As some cyanobacterial species can have both toxic and nontoxic strains, it is important to determine the status of the various species and strains in Florida's waters because management strategies will vary accordingly.

Most studies done to date have not been broad monitoring programs but rather have been specific research projects to address particular cyanobacterial species or toxins. These include, for example, an FDOH/FWC project to determine the potential for microcystin accumulation in fish and monitoring water for the presence of cyanobacteria and/or toxicity by ELISA as part of ongoing, routine, water-quality projects conducted or funded by the Water Management Districts, the FDEP, universities (*e.g.*, UF), or volunteer groups (*e.g.*, UF Lakewatch). The FDEP is conducting an inter-laboratory study to develop standard operating procedures for collecting and analyzing samples of natural cyanobacterial blooms.

Emerging HAB Threats to Public Health

Approximately 70 of the over 100 potentially toxic HAB species occur in Florida waters (Steidinger *et al.*, 1999; see Appendix E for a table of species and their associated toxins). Therefore, proactive sampling and testing for toxicity is desirable, particularly because certain species can produce both nontoxic and toxic strains. With all these emerging HAB-related threats to public health, it is important that blooms, animal mortalities, and shellfish toxicity be investigated. Many state agencies and other institutions currently collect and evaluate water samples for presence of HAB species and toxins, although much more needs to be done. HAB cells are isolated from field blooms, cultures are established, and the toxicity of various geographic strains is determined. Other biota are also tested for specific toxins in parallel with known HAB species. These evaluations determine whether a bloom is producing toxins that could affect public health or living resources.

Some HAB organisms present in Florida are known to produce toxins in other parts of the world, including the Gulf of Mexico, but to date have not been shown to cause human health problems in Florida (*e.g.*, DSP and *Prorocentrum* or *Dinophysis* species). Other organisms have been shown to produce toxins in Florida as well as elsewhere but without any resultant negative impacts or human illnesses (*e.g.*, domoic acid and *Pseudo-nitzschia*). Other toxic HAB species that occur and bloom in Florida waters include *Protoceratium reticulatum*, *Lingulodinium polyedrum*, and *Gonyaulax spinifera*, dinoflagellates that produce yessotoxins (Rhodes *et al.*, 2005; Bowden, 2006). However, no incidents of toxicity from these organisms have been documented in either humans or wildlife in Florida.

Several species of *Coolia* and *Ostreopsis*, both benthic dinoflagellates, also occur in Florida waters. *Coolia monotis* can produce polyether toxins and *Ostreopsis* species can produce palyotoxin-like bioactive compounds. However, the Florida strains have not been tested for toxins, and no known human illnesses have occurred from large concentrations or blooms.

In culture conditions, the amount of toxins produced per cell by some HAB species varies. It is not known whether apparently nontoxic strains have the genes to produce toxins. However, environmental conditions such as temperature, nutrient levels, and light intensity can affect the production of toxins even though the species population contains toxin-producing genes. With emerging HAB problems it is important to know if and what environmental regulators influence toxicity. This information would be critical to prepare response plans and develop effective management strategies.

Diarrheic Shellfish Poisoning

DSP is associated with the aquatic toxin OA, which is produced by the dinoflagellate *Prorocentrum lima* (Murakami *et al.*, 1982), other benthic *Prorocentrum* species (Dickey *et al.*, 1990), and *Dinophysis* species (Yasumoto *et al.*, 1984). This toxin has been detected in shellfish and phytoplankton from the Gulf of Mexico (Dickey *et al.*, 1992). In 2008, Texas closed shellfish beds because of a toxic *Dinophysis* bloom (Campbell *et al.*, 2008). Although the HAB species associated with DSP occur in Florida coastal waters and estuaries, there have been no known cases of DSP from harvested shellfish.

Amnesic Shellfish Poisoning

ASP, caused by the toxin domoic acid, has a history similar to that of DSP in Florida. Although no cases of ASP are known to have occurred from shellfish harvested from Florida coastal or estuarine waters, domoic acid-producing strains of the diatom *Pseudo-nitzschia* spp. are known to bloom there.

Tumor Promoters

Several groups of toxins produced by dinoflagellates and cyanobacteria have been shown to have a variety of short-term effects causing intoxication, but these same toxins can be tumor promoters in the long term. Microcystins, nodularins, OA, dinophysistoxin-1, aplysiatoxins, debromoaplysiatoxin, and lyngbyatoxin-a have all been demonstrated experimentally to be tumorigenic in small mammals or cell assays (Fujiki and Suganuma, 1993; Falconer and Humpage, 1996; Sueoka and Fujiki, 1998). Although the potential role of microalgal toxins in tumor development in marine animals has been postulated (Landsberg, 1995, 1996; Landsberg *et al.*, 1999; Arthur *et al.*, 2006), clearly linked evidence is still lacking.

In addition to the involvement of OA in acute human shellfish poisoning events (DSP), there is an increasing awareness of the potential role of OA and its derivatives as tumor promoters. In two-stage carcinogenesis experiments, OA has been shown to induce skin papillomas and carcinomas in mice and adenomatous hyperplasia and adenocarcinomas in the glandular stomach of rats (Suganuma *et al.*, 1988, 1990; Fujiki *et al.*, 1989; Sakai and Fujiki, 1991; Fujiki and Suganuma, 1993). Dinophysistoxin, an OA derivative, has also been shown to induce tumors in mice (Fujiki *et al.*, 1988). An epidemiological study of digestive-tract cancer mortality of DSP (from OA or dinophysistoxins) was conducted in relation to its distribution. Although there appeared to be a very tentative positive association between the two, Cordier *et al.* (2000) recognized the need for more extensive surveys and in-depth research before any link can be definitively proven.

Fibropapillomatosis (FP) in green turtles is a debilitating neoplastic disease that has reached epizootic levels worldwide. The etiology of FP is unknown, but it has been linked to oncogenic viruses (Herbst, 1994). Toxic benthic dinoflagellates (*Prorocentrum* spp.) are not typically considered tumorigenic agents, but they do have a worldwide distribution and produce tumor-promoting OA (Fujiki and Suganuma, 1993). Benthic *Prorocentrum* spp. are epiphytic on the macroalgae and seagrasses that are normal components of green turtle diets. In the Hawaiian Islands, green turtles consume *Prorocentrum*, and high-risk FP areas are linked to areas where *P. lima* and *P. concavum* are both widespread and abundant. The presence of OA in the tissues of Hawaiian green turtles indicates exposure and that this tumor-promoter may have a potential role in the etiology of FP (Landsberg *et al.*, 1999).

Like OA, lyngbyatoxin-a has been experimentally demonstrated to induce papillomas in two-stage mouse carcinogenesis experiments (Fujiki *et al.*, 1984). Unlike OA, nodularins, and microcystins, lyngbyatoxins promote tumor growth through the activation of protein kinase C, not through protein phosphatase inhibition (Fujiki and Suganuma, 1996). Like benthic *Prorocentrum, Lyngbya majuscula* grows epiphytically on seagrass and macroalgae, which also form the basis of the diet of the herbivorous green turtle (*Chelonia mydas*). In Australia, Arthur *et al.* (2006) demonstrated that green turtles are exposed to, and assimilate, tumor-promoting compounds produced by *Lyngbya*, thus providing a potential for these compounds to be involved in FP. The potential for these tumor promoters to be involved in turtle FP in Florida should also be investigated.

Other Potential HAB Problems

Potential HAB problems in Florida need to be treated in the same manner as are the already emerging HAB threats. This includes statewide monitoring for species and testing for toxins. Event response by FWC covers the entire state. It is triggered by discolored water, dead or dying animals, toxic shellfish, unusual behavior of aquatic animals, and other clues, *e.g.*, respiratory irritation associated with a body of water. FDOH and FWC, together with other state agencies, universities, and private laboratories, use various hotlines and participate in an integrated program for notification and response. This network should be recognized, formalized, and actively maintained. Local CHDs and their personnel should be part of this network and have action or response plans in place to facilitate appropriate and effective activities in the event of a HAB outbreak.

Fish Kills

At least twelve fish-killing (ichthyotoxic) HAB species occur in Florida, including *Alexandrium monilatum, Takayama pulchella, Karenia mikimotoi, Karenia selliformis, Karlodinium veneficum, Prymnesium parvum,* and *Chattonella* spp. (Steidinger *et al.*, 1999; Landsberg, 2002; see Appendix E for a table of species and their associated toxins). These species have the ability to produce toxins, but often blooms can occur and not be

Acknowledgment of Participants

The FHABTF Public Health Technical Panel met in 2004, 2005, and 2006 at the FWC–FWRI. The purpose was threefold: to familiarize county health personnel with the different HABs in Florida, to identify the public health and environmental effects of a particular bloom, and to identify the resources needed for developing public health response plans at the county level. The meetings were in part a review of currently known harmful algae and the consequences of their presence in Florida waters, and in part brainstorming on the issues, *e.g.*, monitoring, research, agency coordination, public health information, education, and communication. Participants included the following public health, environmental, natural resource, agriculture, and research professionals from state agencies, universities, and private laboratories.

We thank the following for their participation and continued interest in this joint FWC–FDOH project in cooperation with other federal and state agencies, laboratories, and universities.

Abbott (Shone), Meghan – FWC
Alaimo, Antoinette – FDOH
Backer, Lorraine – CDC
Bigsby, Patricia – FDOH
Blackmore, Carina – FDOH
Bodager, Dean – FDOH
Boler, Richard – EPCHC
Bolestra, Rob – FDOH
Borroto-Ponce, Rene – FDOH
Bryan, Scott – FDOH
Campbell, Dean – SJRWMD
Degenaro, Stephanie – FDOH
DeThomasis, JoEllen – FDOH
Dobberfuhl, Dean – SJRWMD
Donnelly, Maria – FDOH
Downing, Brandy – FDOH
Drake, Judy – FDOH
Drew, Richard – FDEP
Faconti, Victor – FDOH
Flanery, Mike – FDOH
Fleming, Lora – U of M
Flewelling, Leanne – FWC
Friedman, Mike – FDOH
Fugitt, Marian – FDEP
Fulton, Jason – FDOH
Girardin, David – SJRWMD
Grant, Val – FDOH
Halscott, Kenneth – FDOH
Hammond, Roberta – FDOH
Harvey, Richard – EPA
Heil, Cindy – FWC
Heil, David – FDACS
Higman, John – SJRWMD
Hutchinson, Richard – FDOH
Jackow, George – FDOH
Jerez, Eva – PCC
Kent, Steve – FDEP
Ketchen, Sharon – FDOH
King, Joe – FDEP
Kirkpatrick, Barb – MML
Koerner, David – FDOH
Kowal, Laura – FDOH
Lander, Mark – FDOH
Landsberg, Jan – FWC
Lazensky, Becky – FDOH
Luce, Christie – FDOH
Maier, Gary – FDOH
Melling, Russ – FDOH
Nelson, Jennifer – FDEP
Nelson, Sascha – FDOH
Odongo, George – FDOH
O'Reilly, Andrew – USGS
Patch, Sonal – FDOH
Pawlowicz, Marek – FDOH
Pettit, Karen – MCWTP
Pfeuffer, Richard – SFWMD
Pink, Jack – FDOH
Polk, David – FDOH
Pouso, David – FDOH
Prager, Ellen – Earth$_2$Ocean, Inc.
Rakestraw, Richard – FDEP
Reed, Gale – FDOH
Reich, Andy – FDOH
Reinhold, Todd – FDOH
Riskowitz, Kevin – City of St. Petersburg
Scheidt, Dan – EPA
Schelble, Chip – FDOH
Seay, Briana – FWC
Shapiro, Jerne – FDOH
South, Robert – FDOH
Stanek, Paul – FDOH
Steidinger, Karen – USF
Stephan, Wendy – U of M
Stripling, Terri – FDOH
Terzagian, Robin – FDOH
Thornton, Pete – FDOH
Traynor, Sharleen – FDOH
Waldron, Jennifer – FDOH
Watford, Kim – FDOH
Weisman, Richard – U of M
Whiting, David – FDEP
Williams, Chris – GWL
Wilson, Emily – FDOH
Wilson, Yvette – FDOH
Windham, Donald – FDOH
Winn, Sarah – FDOH
Zager, Hunter – FDOH
Zaheer, Saad – FDOH
Zorros, Tim – FDOH

Resource Guide for Public Health Response to Harmful Algal Blooms in Florida

Based on Recommendations of the Florida Harmful Algal Bloom Task Force Public Health Technical Panel

G. Meghan Abbott[1*]
Jan H. Landsberg[1]
Andrew R. Reich[2]
Karen A. Steidinger[1,3]
Sharon Ketchen[2]
Carina Blackmore[2]

[1]Florida Fish and Wildlife Conservation Commission
Fish and Wildlife Research Institute
100 Eighth Avenue Southeast
St. Petersburg, Florida 33701 USA

[2]Florida Department of Health
Division of Environmental Health
4052 Bald Cypress Way
Tallahassee, Florida 32399 USA

[3]University of South Florida
Florida Institute of Oceanography
830 First Street South
St. Petersburg, Florida 33701 USA

**Present address follows Acknowledgments*

Florida Fish and Wildlife Conservation Commission
FWRI Technical Report TR-14

2009