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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

Florida Fish and Wildlife Conservation Commission

FLORIDA DEPARTMENT OF HEALTH

FLORIDA FISH AND WILDLIFE CONSERVATION COMMISSION

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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

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Cover Photographs

Center: Mercenaria mercenaria hard clams *(Florida Fish and Wildlife Conservation Commission). Clockwise from upper left:* Saxitoxin puffer fish poisoning warning sign in the Indian River Lagoon, Florida *(Florida Department of Health).* Cyanobacteria bloom in Crescent Lake outflow into Coffee Pot Bayou, Florida *(Florida Fish and Wildlife Conservation Commission).* Red tide aerosol studies (*Mote Marine Laboratory*). Florida red tide fish kill, July 2005 (*Florida Fish and Wildlife Conservation Commission*).

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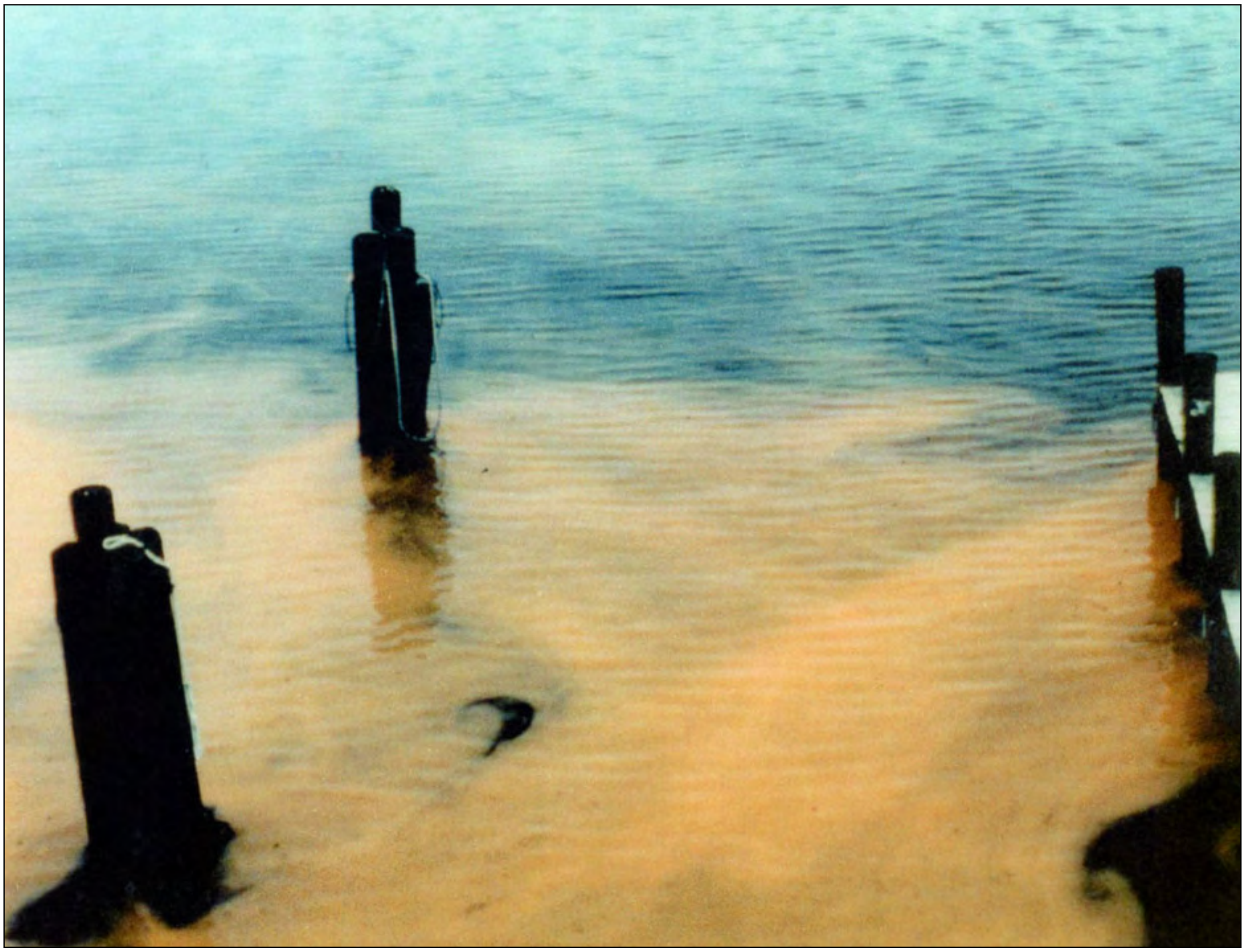

Dinoflagellate bloom in Bayboro Harbor, St. Petersburg, Florida

Preface

In October 1997, Virginia Wetherell, then Secretary of the Florida Department of Environmental Protection, conceived and created the Florida Harmful Algal Bloom Task Force (FHABTF) as an *ad hoc* group to identify gaps in information on harmful algal blooms (HABs) in Florida, particularly *Karenia brevis* red tides and potential *Pfiesteria* fish kills. Secretary Wetherell invited Dr. James Howell, then Secretary of the Florida Department of Health (FDOH), to co-chair the *ad hoc* task force. The FHABTF received a legislative mandate in July 1999, Florida Statute (F.S.) Chapter (Ch.) 370.06092 (now F.S. Ch. 379.2271).

One product of the FHABTF, "Harmful Algal Blooms in Florida" (Steidinger *et al.,* 1999), was an unpublished technical report presented to the Florida legislature in October 1999. Recommendations from this report contributed to the drafting of F.S. Ch. 370.06092 (now F.S. Ch. 379.2271), which assigned four tasks for the FHABTF. As of 2003, only three had been completed:

> *"(a) Review the status and adequacy of information for monitoring physical, chemical, biological, economic, and public health factors affecting harmful algal blooms in Florida;*
> *"(b) Develop research and monitoring priorities for harmful algal blooms in Florida, including detection, prediction, mitigation and control; …and*
> *"(d) Make recommendations to the Florida Fish and Wildlife Research Institute for research, detection, monitoring, prediction, mitigation, and control of harmful algal blooms in Florida."*
>
> F.S. Ch. 379.2271

The remaining task (F.S. Ch. 379.2271 [2][c]) was to "develop recommendations that can be implemented by state and local governments to develop a response plan and to predict, mitigate, and control the effects of harmful algal blooms." In 2003, the Florida Fish and Wildlife Conservation Commission (FWC) Fish and Wildlife Research Institute (FWRI) created the FHABTF Public Health Technical Panel. In the same year, FWC–FWRI received funds from the FDOH (made available by the Centers for Disease Control and Prevention Grant U50-CCU423360-01) for support of this initiative to assist in the development of recommendations for an integrated public health environmental monitoring response plan. The portion of the statute on "predict, mitigate, and control the effects of harmful algal blooms" was addressed in part by the Red Tide Control and Mitigation Program administered by FWC–FWRI. However, legislative budget cuts that began in 2008 threaten the program's future.

The Public Health Technical Panel first met in October 2004 to discuss a framework for local public health response plans. In the next phase, two workshops on informational needs for the development of local public health response plans were conducted at FWC–FWRI in St. Petersburg. The first workshop titled "Florida Public Health Meeting on Harmful Algal Blooms and their Effects" was held 27–28 September 2005. The second workshop titled "Florida Harmful Algal Bloom Public Health Agenda: Information for Developing Local Response Capacity" was held 9–10 August 2006. At the second workshop specific recommendations were made by participants on informational materials needed for a user-friendly guide to address county public health response to HABs. The two workshops were co-chaired by Jan Landsberg (FWC) and Andrew Reich (FDOH) and were attended by public health, environmental, natural resource, agriculture, and research professionals from state agencies, universities, and private laboratories (see Acknowledgement of Participants).

This document is an extension of the activities performed by the Public Health Technical Panel, and addresses in part tasks directed by the legislatively created FHABTF. The final phase is the actual development of public health response plans, and this will be done by local county health departments assisted by the FDOH Aquatic Toxins Program.

Table of Contents

Figures

Tables

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.

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The FHABTF Public Health Technical Panel was convened specifically to provide guidance and recommendations on materials needed to develop plans for local public health response to HABs. Many thanks to FDOH staff JoEllen DeThomasis and Sharon Watkins, as well as FWC–FWRI staff Leanne Flewelling, Llyn French, Craig Harmak, Cindy Heil, James Quinn, Jr., and Ruth Reese for their various review and graphics contributions to this Guide, and to Dr. Ellen Prager of Earth$_2$Ocean, Inc., for facilitating the 2006 FHABTF Public Health Technical Panel meeting.

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Executive Summary

Harmful algal blooms adversely affect Florida's environment, economy, and human health. In recent years, more HAB species and toxins have been identified, and toxins have appeared unexpectedly in algae that were once presumed to be nontoxic. HABs are increasing in frequency and geographic range, causing global concern over an increasing public health risk.

The FHABTF was charged with investigating HABs and assessing their potential effects on living aquatic resources and public health. This charge included investigating HAB events such as red tides and newly emerging issues such as the potential for the fish-killing dinoflagellate *Pfiesteria piscicida* to become a threat in Florida. In addition, the FHABTF was to evaluate critical HAB issues and make recommendations for action. A Technical Advisory Group (TAG) was also appointed to assist the task force. The TAG developed a resource document, "Harmful Algal Blooms in Florida," that identified major Florida HABs; discussed the history and economic, natural-resource, and public health effects of HABs; and made recommendations for action. This document was reviewed by the Florida legislature which passed Florida Statutes (F.S.) Ch. 379.2271 and Ch. 379.2272 (formerly Ch. 370.06092 and Ch. 310.06093) in 1999, charging the task force with identifying gaps in research and information and developing strategies and recommendations for response.

In 2003, the FHABTF Public Health Technical Panel was created in response to F.S. Ch. 379.2271 section 2(c), "Develop recommendations that can be implemented by state and local governments to develop a response plan and to predict, mitigate, and control the effects of harmful algal blooms." This document is the resulting guide for state and local governments to facilitate the development of local public health HAB response plans.

This technical manual has two major components. The first provides background information for guiding development of local response plans and quick-reference guides for public health HAB response. The second presents a methodology for developing flowcharts and further technical information related to public health HAB response. The major topics include the following:

- review of current literature on HABs significant to public health in Florida
- identification of present federal, state, and local governmental authority over, and responsibility for, response activities related to HABs
- available monitoring and surveillance databases
- current human health and animal surveillance systems
- public health regulatory guidelines (state, national, and international)
- available outreach resources
- current management strategies for mitigation of HABs in Florida
- priority research and policy needs
- examples of generic response flowcharts for environmental and case investigations
- maps identifying specific areas of Florida at high risk for HAB exposures
- medical fact sheets, clinical case definitions and reporting requirements for HAB-related human illnesses, including neurotoxic shellfish poisoning, brevetoxin-associated respiratory syndrome (also known as red tide cough), ciguatera fish poisoning, saxitoxin puffer fish poisoning, and blue-green algae toxin (cyanotoxin) poisoning and illness, with a quick reference guide to all
- extensive overview of toxins associated with HAB species in Florida
- guidelines for cyanobacteria in recreational waters
- other significant literature related to the effects of HABs on humans
- list of important agency contacts, scientists, and managers

Chapter 1
Background on Harmful Algal Blooms

Purpose *To identify existing HABs and their related toxins; to review their backgrounds and ecologies and their effects on public health, living resources, and the economy; and to review existing monitoring operations. To update and expand on information originally printed in the FHABTF white paper, "Harmful Algal Blooms in Florida" (Steidinger* et al., *1999).*

The following is an overview of the current HABs in Florida, their related toxins, and associated illnesses. These include brevetoxins and neurotoxic shellfish poisoning, saxitoxins and saxitoxin puffer fish poisoning, ciguatoxins and ciguatera fish poisoning, as well as cyanotoxins and/or cyanobacterial exposures and their associated health concerns. Sections are included on the background, ecology, human health effects, living-resource effects, economic effects, and the existing operations for monitoring and responding to each HAB. Additional sections address emerging or potential HAB threats to public health, including fish kills, diarrheic shellfish poisoning, amnesic shellfish poisoning, and HAB toxins as tumor promotors. Other HABs of interest include Pfiesteria *and* Pfiesteria*-like species. This information may be used as a background guide to prioritize regional HAB issues in the design of response plans.*

Introduction

Harmful algal blooms are global phenomena occuring in almost all aquatic environments from open seas to freshwater lakes. In the marine environment, they are sometimes known as red tides. However, they are neither always red nor even visible to the unaided human eye and are not necessarily associated with tides. The term "red tide" is a misnomer and its replacement "harmful algal blooms" is more descriptive of the events that occur (Anderson, 1995).

"Harmful" describes the algae usually associated with toxic events during which animals and humans sicken or even die; however, even nontoxic algae can also impact humans, animals, and the entire ecological community structure. For example, animal mortalities associated with HABs can result from indirect effects such as the formation of toxic sulfides or increased nitrogenous byproducts in the water. As cells in a bloom multiply, die, and decompose, they use so much oxygen that other organisms in the water may not be able to survive. Declining water quality can lead to chronic animal disease or mortalities, species avoidance of an area, and reduced feeding (Landsberg, 2002). Mass marine mortalities may result in piles of decomposing organisms on the beaches, adversely affecting beach quality and ultimately human use of these areas. Decomposing organisms may also contribute to bacteria-associated beach and water quality degradation although this issue is not well researched. "Algal" usually refers to microscopic algae, which include phytoplankton that can cause these harmful effects. Globally, an increasing number of microalgae such as dinoflagellates and cyanobacteria have been found to produce toxins. "Bloom" means that the microalgae are present at high enough concentrations in the water to have an effect—whether it is human illness, sick or dead animals, or change in the ecological community structure of a particular habitat.

Most HAB microalgae have photosynthetic pigments. A bloom of these pigmented algae can color the water in many hues including red, brown, green, yellow, and white. There are more than 100 reported toxic or harmful microalgae species (about 2% of the world's phytoplankton) (Landsberg, 2002); over 70% of those are dinoflagellates.

With more than 50 marine and 20 freshwater harmful algal species present, Florida's HABs have the potential to affect public health, cause economic losses, and affect living marine, freshwater, and terrestrial resources (Fleming *et al.,* 1998; Steidinger *et al.,* 1999; Williams *et al.,* 2001; Backer *et al.,* 2003a; Kirkpatrick *et al.,* 2004; Landsberg *et al.,* 2006). The most significant toxins produced by HABs in Florida include saxitoxins (STXs), brevetoxins (PbTXs), ciguatoxins (CTXs) in marine waters, and cyanotoxins, *e.g.,* microcystins, cylindrospermopsins, and lyngbyatoxins, in fresh water. Elsewhere, STXs are produced by multiple dinoflagellate species and are typically associated with paralytic shellfish poisoning (PSP). In Florida, STX-caused illnesses have only been from saxitoxin puffer fish poisoning (SPFP). STX is produced by the dinoflagellate *Pyrodinium bahamense.* Brevetoxins are produced by the dinoflagellate *K. brevis* and cause neurotoxic shellfish poisoning (NSP); brevetoxicosis also results in widescale animal mortalities. Brevetoxin-associated respiratory illness occurs after inhalation of marine aerosols containing the toxin. Wind and wave action can lyse cells and release the toxins, which become airborne in jet spray and create a red tide aerosol. Ciguatoxins (CTXs) produced by the benthic dinoflagellate *Gambierdiscus toxicus* cause the tropical and subtropical poisoning known as ciguatera fish poisoning (CFP). Cyanotoxins and their corresponding algal genera include microcystins, *Microcystis;* lyngbyatoxins, *Lyngbya;* anatoxins, *Anabaena;* and cylindrospermopsin, *Cylindrospermopsis.* However, many other species are also known to produce cyanotoxins and some may produce multiple toxins. Some cyanotoxins have been found in the surface layer of freshwater during blooms and ingestion of affected raw water has been associated with human illness elsewhere and death of livestock or pets. There are also anecdotal reports of dermatitis and skin irritation after exposure to red tide and cyanobacterial blooms.

Other toxic algae have also been found in Florida. These include the domoic-acid–producing diatom, *Pseudo-nitzschia,* which is associated with amnesic shellfish poisoning (ASP); and the dinoflagellates *Dinophysis* and *Prorocentrum,* which produce okadaic acid (OA). This toxin causes the illness diarrheic shellfish poisoning (DSP). However, neither of these illnesses has yet been documented in Florida.

Equally important, HABs negatively impact living resources and ecosystem health. For example, at least 12 species of HABs are known to be ichthyotoxic, contributing to many fish-kills, and hence have fishery implications in Florida. These toxins are not currently known to be public health risks.

Harmful macroalgal blooms in Florida coastal and estuarine waters can also affect reefs and benthic communities. Macroalgal blooms, such as red drift algae common to Florida's southwest coast, can alter marine habitats by smothering benthic communities, reducing species diversity and abundances, and leading to animal disease (Landsberg, 1995; Lapointe *et al.,* 2005). Beach environments can be degraded by dead fish from kills or large amounts of macroalgae washing ashore. However, these blooms are not known to affect human health.

Economic impacts from HABs are often difficult to assess, but one report (Hoagland *et al.,* 2002) estimated that between 1987 and 1992, the average annual loss of revenue from all HABs in the United States was 50 million dollars (using year 2000 dollars). This is a conservative estimate. A breakdown of the estimated costs suggested 45% for impacts to public health, 37% for commercial fisheries, 13% for recreation and tourism, and 4% for monitoring and management.

Public health effects include the costs of illness-related loss of wages and productivity and the costs of medical treatment and event investigation. The losses incurred by commercial fisheries include those in aquaculture facilities due to contamination from toxic HAB blooms as well as a reduction in public demand due to reported human illnesses or poisonings. Losses to the wild harvest are harder to measure because identifying the exact cause of many fish and shellfish kills is not possible and quantifying the effect on the fishery is complicated by the fact that kills always include "trash fish" of no commercial value. Costs to the recreation and tourism industries are vast, including losses from hotels, restaurants, and recreational fisheries affected by HAB events. Various agencies are involved with regular water quality and shellfish monitoring, but all of them have other related management activities, making it difficult to separate the costs of HAB-specific events (Hoagland *et al.,* 2002).

Brevetoxins and Neurotoxic Shellfish Poisoning

Background

Karenia brevis (also known as Florida red tide) is a neritic dinoflagellate found in open and nearshore areas of the Gulf of Mexico and southeastern U.S.A. Blooms of *K. brevis* have been recorded from off the west coast of Florida to the Mexican Yucatan peninsula. Although the majority of *K. brevis* blooms occur on the west coast of Florida, these red tides occasionally become entrained in circulation features along southwestern Florida and are transported into the Gulf Stream via the Florida Current and up the east coast of the United States. The toxins produced by *K. brevis,* brevetoxins, affect humans and a wide diversity of aquatic organisms.

The first documented report of fish kills along Florida's west coast attributed to red tide occurred in 1844, with the first reported case of human illness from eating "tainted" shellfish occurring in 1880 (Walker, 1884). Mrs. Charles Hoy experienced symptoms of NSP after consuming toxic shellfish from Tampa Bay. During that same event, dead fish and sick and dying seabirds were also reported. Taylor (1917) reported the occurrence of a toxic "gas" during the 1916 red tide that caused essentially the same symptoms that would be described today for aerosolized brevetoxins. The "gas" was later determined to be particulates in sea spray that irritated the respiratory passages and eyes (Woodcock, 1948). Today we know that brevetoxins are low-molecular-weight, lipid-soluble, polyether toxins that can be associated with cell fragments or particles in seawater. Because *K. brevis* cells are unarmored and fragile, their lysis at the sea surface can release brevetoxins that become aerosolized and highly toxic above the air–water interface (Pierce, 1986; Pierce *et al.,* 1990).

Seafoam can be more than 100 times higher in toxicity than seawater itself.

Other *Karenia* species found in the Gulf are *K. mikimotoi, K. papilionacea, K. selliformis, K. longicanalis,* and *Karenia* spp., along with a related species *Karlodinium veneficum* (Haywood *et al.,* 2004). Some of these species are toxic but are not known to produce brevetoxin. For example, *Karenia selliformis* produces gymnodimine (Seki *et al.,* 1995; Haywood *et al.,* 2004), whereas *Karlodinium* produces karlotoxins (Deeds *et al.,* 2002). There have been no reported cases of human illnesses in Florida caused by toxic exposures from these latter species. As more work is done on harmful algae, more potentially harmful species are being described.

Ecology

Karenia brevis red tides have been documented in almost all years since funding was initiated for surveillance and research in the 1960s (Steidinger, 2009; FWC, unpublished data). *Karenia brevis* blooms are most common in the fall and least common in February and March, but they can occur in any month. Blooms do not survive well in seawater with salinity less than 24 psu, but the species is well adapted to the west Florida shelf environment and is influenced by specific physical and oceanographic circulation features and a range of nutrient sources. *Karenia brevis* populations do not demonstrate explosive growth as the population increases but the population can double every 3 days. The successive stages of a bloom are initiation, growth, maintenance, and termination or transport away from the area. The initial appearance of *K. brevis* occurs on the outer or mid-shelf region of the Gulf of Mexico with growth in the mid-shelf region, followed by movement inshore. It often concentrates at a frontal system and is then transported by winds and currents up and down Florida's Gulf coast.

Exposures to toxins are coincident with the bloom or may continue well after the event subsides. Toxins move up through the food web from filter feeders, such as shellfish, to organisms at higher trophic levels such as fish, dolphins, manatees, and birds. Adverse effects on these species may be seen for weeks post-bloom (Flewelling *et al.,* 2005; Landsberg *et al.,* 2009).

Although Florida red tide blooms are natural events that start offshore, questions remain as to whether land-based anthropogenic sources may influence their longevity and persistence once they come inshore. Several factors, particularly salinity and nutrient levels (Landsberg and Steidinger, 1998; Mulholland *et al.,* 2004), are often considered influential, but the issue of nutrients is complex. *Karenia brevis* requires nitrogen, phosphorus, trace metals, and other major and minor nutrients for basic growth and is able to use organics efficiently. Offshore, *K. brevis* is adapted to an oligotrophic environment (*i.e.,* waters low in nutrients and biomass). It may be stimulated by blooms of the blue-green algae *Trichodesmium* (Walsh and Steidinger, 2001), which release nutrients during growth and senescence. These nutrients (*e.g.,* organic nitrogen) have been shown to be taken up by *K. brevis* (Mulholland *et al.,* 2004, 2006). However, there are other sources of nutrients: *e.g.,* rich marine and terrestrial phosphate deposits, estuarine flux, regenerated nutrients from benthic diatom blooms, and a very significant self-generating source—the dead fish caused by a *Karenia* bloom (Vargo, 2009; Walsh *et al.,* 2009).

Effects on Human Health

Karenia brevis produces a suite of neurotoxins, chemicals that affect nerve conduction, collectively known as brevetoxins. There have been no known human fatalities associated with exposure to brevetoxins. (This contrasts with other HAB-related toxins such as STXs, ciguatoxins, cyanotoxins, and domoic acid which have caused fatalities in other regions; however, no fatalities have been reported originating from blooms in the Gulf of Mexico). Although the activity of the parent toxins and their derivatives has been studied, the effects of brevetoxin metabolites are still not well understood. One confounding factor in potency is the coproduction by *K. brevis* of a toxin antagonist, known as brevenal (Bourdelais *et al.,* 2004). The ability of brevenal to modulate the effects of brevetoxins and metabolites is not understood.

Brevetoxins can affect people through several routes of exposure. Brevetoxin-related illnesses are typically due to acute exposure such as ingestion of toxic shellfish or through inhalation of toxic aerosol. However, there is no information on the effects of periodic chronic exposure to low levels of brevetoxin or brevetoxin metabolites.

NSP occurs from ingestion of edible bivalves that have accumulated brevetoxins from *K. brevis* cells. Symptoms of NSP include numbness and tingling sensations in the lips, mouth, and extremities; nausea; vomiting; diarrhea; slurred speech; muscle weakness; and ataxia. Vertigo, hot–cold reversals, pupil dilation, respiratory distress, and partial paralysis have also been reported. Full recovery typically takes two to three days (see Appendix B, Medical Fact Sheets and Case Definitions). Although NSP is known to cause moderate symptoms, a significant portion of cases require hospitalization for brief periods.

NSP is a reportable disease in Florida although it is probably underreported due partially to misdiagnosis and undetected milder clinical cases. While no

FWC image

Florida red tide fish kill, July 2005.

human mortalities have been reported from brevetoxicosis, there have been four separate incidents in which patients (one less than five years old, two teenagers, and one adult with other underlying medical conditions) required breathing support (Steidinger *et al.*, 1998; Poli *et al.*, 2000; Watkins *et al.*, 2008). In 2005, four cases of NSP were reported in Florida and more than 20 in 2006 (Terzagian, 2006; Watkins *et al.*, 2008; Florida Department of Health [FDOH] Merlin®, unpublished data).

There are fewer than 100 documented case histories of NSP. About 50 of these illnesses were documented in North Carolina in 1987 when a *K. brevis* bloom was transported from the west coast to the east coast of Florida and up to the Carolinas via the Gulf Stream. A Gulf Stream intrusion off the North Carolina coast transported the bloom inshore to estuaries which then resulted in toxic shellfish beds (Fowler and Tester, 1989; Morris *et al.*, 1991). Many of the other documented cases have occurred in Florida. There have been repeated outbreaks of NSP off Florida's southwest coast during the years 1995, 1996, 2001, 2005, and 2006 and most frequently in Lee County. All of these have been associated with recreationally harvested shellfish, *e.g., Chione* clams and fragile surf clams, *Mactroma fragilis,* although in some instances the implicated species has been another commonly harvested shellfish or is unknown (Steidinger *et al.*, 1998; Poli *et al.*, 2000; Terzagian, 2006; Watkins *et al.*, 2008; FWC–FWRI, unpublished data). As with the other marine toxins, brevetoxins are not altered by cooking or freezing and cannot be detected by taste or smell, all factors that increase the potential for human health impacts.

A second exposure route is through inhalation of marine aerosols containing brevetoxin originating from ruptured *K. brevis* cells via bubble-mediated transport (Pierce *et al.*, 1990, 2003). Brevetoxins and cell fragments from *K. brevis* can cause upper and lower respiratory symptoms. Humans can experience eye irritation, nonproductive cough, and broncho-constriction (Baden *et al.*, 1995; Backer *et al.*, 2003b, 2005; Kirkpatrick *et al.*, 2004; Fleming *et al.*, 2007) from exposure to the toxic aerosol. These symptoms are reversible upon removal of the irritant source; however, there are no comprehensive epidemiological studies on chronic exposures during a Florida red tide event or on lingering symptoms post-exposure. People with a history of respiratory illness such as asthma, bronchitis, or chronic obstructive pulmonary disease (COPD) may be at risk for longer-term effects. In asthmatics, effects have been shown to last up to 5 days after a beach exposure (Kirkpatrick *et al.*, 2006, 2008). The FDOH, in collaboration with the University of Miami (U of M), the Centers for Disease Control and Prevention (CDC), the Mote Marine Laboratory (MML), and other partners, are conducting investigations on human risks associated with exposure to this toxic aerosol (Backer *et al.,* 2005; Benson *et al.,* 2005; Fleming *et al.,* 2005a,b). These include studies on trans-placental transport of brevetoxins, chronic effects of exposure, and emergency room admission rates for respiratory illness. For additional discussions on human health effects, see Backer *et al.,* 2003b, Kirkpatrick *et al.,* 2004. A comprehensive review of the public health aspects of red tide appears in *Environmental Health Perspectives,* Mini-Monograph: Brevetoxins, 113(5): 618–657 (May 2005).

Rare cases of other health effects include anecdotal reports of contact dermatitis from exposure to Florida red tide blooms and instances of puncture wounds from contact with spines of beached dead fish. There have been no documented cases of human illness associated with the consumption of fish during Florida red tide blooms.

Effects on Living Resources

Historically, of all the HABs in Florida, brevetoxin-producing *K. brevis* red tides have caused the most significant problems, with sustained threats from NSP, aerosolized toxins, and annual mass mortalities of thousands of fish and invertebrates and frequent mass mortalities of hundreds of endangered marine mammals, sea turtles, and birds (Gunter *et al.,* 1948; Rounsefell and Nelson, 1966; Steidinger *et al.,* 1973; Landsberg, 2002; Flewelling, 2008).

There is a long history of marine mammal die-offs during Florida's red tide blooms, including events in 1947–1948 (Gunter *et al.,* 1948; Rounsefell and Nelson, 1966); 1963 and 1982 (Layne, 1965; O'Shea *et al.,* 1991); and 1987–1988 (Geraci, 1989). Large-scale mass mortalities of manatees occurred in Florida in 1996, 2002, 2003, 2005, 2006, and 2007 (Bossart *et al.,* 1998, 2002; Landsberg and Steidinger, 1998; Flewelling *et al.,* 2005; Landsberg *et al.,* 2009; FWC–FWRI, unpublished data); and of bottlenose dolphins in 1999–2000 and 2004 (Flewelling *et al.,* 2005; Landsberg *et al.,* 2009; B. Mase and T. Leighfield, NOAA, personal communications). Brevetoxins can be transferred through the food chain and are accumulated in or transferred by biota at many trophic levels. The trophic transfer of brevetoxins in the food web is a complex phenomenon, one that is far more complicated than originally conceived (Flewelling *et al.,* 2005; Landsberg *et al.,* 2009).

Investigations of toxic fish are ongoing. Brevetoxins and derivatives have been found in tissues of red tide-exposed fish, including muscle, liver, kidney, and other body parts, as well as in stomach contents (Naar *et al.,* 2007). The highest toxin concentrations reported have been in planktivorous fishes that can feed on red tide (Flewelling, 2008). These fish concentrate high levels of brevetoxins in their viscera and become toxic to higher predators including such marine mammals as dolphins, because these predators eat whole fish. In omnivorous and carnivorous fishes, the highest levels of brevetoxins and their metabolites (as determined by enzyme linked immunosorbent assay [ELISA]) typically occur in liver tissue, and if fishermen gut their fish and eat only the muscle, they should not become sick. To date, in an ongoing study measuring brevetoxin concentrations in the tissues of live-caught fish, analyses of more than 2,500 fish have not indicated a risk to human health from consumption of the fillet (FWC, unpublished data). In addition, toxins in the muscle are quickly depurated or cleared by normal metabolic processes (Naar *et al.,* 2007).

In 2005, a persistent *K. brevis* bloom off the west coast of Florida was responsible for hundreds of thousands of deaths of different species of marine mammals, turtles, seabirds, fish, and invertebrates. The 2005 event even contributed to a benthic mortality off Tampa Bay (Landsberg *et al.,* 2009), partly attributable to low dissolved oxygen associated with the large biomass of dead and dying organic material and from brevetoxins that settled to the bottom, similar to a 1971 event (Smith, 1975).

In 2003, at least eight domestic dogs from the beach area of Little Gasparilla Island in southwestern Florida were admitted to local veterinary clinics after being reportedly affected by exposure to brevetoxins during a highly concentrated Florida red tide event (Landsberg *et al.,* 2003). Birds are also affected by brevetoxins, especially those that consume toxic shellfish or fish. Substantial numbers of sick and dying cormorants have occurred with red tide outbreaks along the west Florida coast since 1995 (Kreuder *et al.,* 2002; Landsberg *et al.,* 2007; FWC, unpublished data) and were documented in the 1880 red tide.

Economic Effects

Two 3- to 5-month red tide blooms off Florida caused $15–$20 million in losses to local communities in the 1970s (Habas and Gilbert, 1974, 1975). In 1987, Florida red tide transported from Florida by the Gulf Stream resulted in closures of shellfish-harvesting areas in North Carolina with an economic loss of $25 million (Tester and Fowler, 1990). Those who live and work on the beach note that businesses, tourism, and community recreational activities are adversely affected by *K. brevis* red tides (*e.g.,* Longboat Key, from

1994–1996; Boesch *et al.,* 1997), but current data documenting actual losses is limited. Morgan and Larkin (2006) reported that Florida red tide impacts between 1995 and 2000 in the Fort Walton Beach and Destin areas of Okaloosa County alone resulted in combined monthly losses of nearly $6.5 million for businesses such as restaurants and hotels. Another study (Morgan *et al.,* 2007), in which coastal managers were surveyed to determine associated costs of red tide events to public beaches, four counties (Pinellas, Sarasota, Lee, and Collier) and two cities (Longboat Key and Naples) gave actual figures for the period of 2004 through 2007. These total costs of $653,890 were primarily for beach cleanup (including labor, equipment, supplies, and vendor fees) and were paid for by tourism tax dollars.

The difficulty in calculating economic effects is due to the variety of direct adverse effects on a particular area, ranging from public health and management costs to the displacement of certain activities such as tourism and fisheries to the benefit of other areas (Backer, 2009). Protocols for collecting such data are being evaluated by economists at the University of Florida (C. Adams, personal communication), and through a collaborative study between MML and Woods Hole Oceanographic Institution (WHOI) (B. Kirkpatrick, personal communication).

Existing Monitoring Operations

Regular monitoring of Gulf waters can help predict the movement of red tides to inshore areas from offshore. The forecast helps to predict potential risks of human exposure to brevetoxins—either through the consumption of toxic shellfish or through inhalation of aerosolized toxic particles. One method used to monitor *K. brevis* blooms is to collect seawater samples and examine these samples microscopically for the presence of toxic species. Although the majority of *K. brevis* monitoring information is collected from inshore land-based samples, this is often supplemented by event-response-targeted monitoring, offshore samples provided by a volunteer sampling program, or preplanned cruises with research vessels on transects out to 80 km or more offshore. The FWC–FWRI monitors west coast waters in cooperation with other state regulatory agencies, *e.g.,* Florida Department of Agriculture and Consumer Services (FDACS), FDOH, and Florida Department of Environmental Protection (FDEP); a volunteer network of boaters, charter boat captains, fishermen, and other citizens; and MML. All analyses involve *in situ* testing, onboard testing, or onshore laboratory testing. Results are posted weekly on the FWC–FWRI Web site, http://research.myFWC.com, and include data from a variety of sources. In addition, there is a toll-free number, 1-866-300-9399, to access current Florida red tide monitoring information (Heil and Steidinger, 2009).

Another source of monitoring data is from remote sensing devices, which use several different methodologies. The results reported in the National Oceanic and Atmospheric Administration (NOAA) HAB Bulletin use satellite imagery, which detects chlorophyll *a* concentrations. This determination is not organism-specific, and the chlorophyll *a* may come from a number of sources including blue-green algae, macroalgae, or *K. brevis.* This method requires verification by direct bloom sampling and microscopic identification during all bloom stages. Potential bloom areas are identified using an algorithm which uses the weekly changes in chlorophyll *a* concentrations and the local wind field to predict potential bloom events. Additional information on this methodology is available on the NOAA HAB Web site, http://coastwatch.noaa.gov/hab/bulletins_ms.htm. The Center for Prediction of Red Tides collaboration between the FWC–FWRI and the University of South Florida College of Marine Science has begun testing the application of algorithms that detect *Karenia* and *Trichodesmium* specifically using the unique reflectance signatures of chlorophyll *a* for these specific organisms. Combined with model forecasts based upon ocean current observations and wind measurements, this technology holds promise for species-specific monitoring by satellites of *Karenia* blooms and forecasting daily bloom movements and their potential effects.

Toxin concentrations in seawater are quantified by various laboratory methods, including the ELISA test, a receptor binding assay (RBA), or liquid chromatography–mass spectrometry (LC–MS). Tests are being done to evaluate whether a relationship exists between toxin concentrations and cell counts of *K. brevis.* Water concentrations of toxins vary because of cell lyses and photo-oxidation, particularly inshore after a bloom fully develops. The toxin antagonist brevenal may also play a role in water toxin concentration. Preliminary data suggest that it is not realistic to compare cell counts with toxin levels or potency because both the physiological state of the bloom and the seawater temperature can affect production of toxins, their potency, and the conversion of specific toxins to less potent metabolites. In-water testing is time- and personnel-intensive, but scientists are moving toward new technologies for rapid assessments that will allow near-real-time identification and quantification of species and toxins. Blooms can then be monitored, and the information acquired can be used to forecast movement or to initialize 3-D mathematical models.

PUBLIC HEALTH

SHELLFISH

To protect public health during bloom events, shellfish areas are closed to harvesting by FDACS Division of Aquaculture when *K. brevis* cell counts are above 5,000 cells per liter. They are re-opened when mouse bioassay (MBA) test results provided by FWC–FWRI are acceptable (less than 20 mouse units [MU] per 100 g of shellfish meats), and cell counts return to background levels, less than 1,000 cells per liter. FDACS maintains a Web site that lists shellfish area closures (http://www.floridaaquaculture.com/SEAS/SEAS_mngmt.htm). This protocol is in compliance with Florida's Marine Biotoxin Control Plan (FDACS, 2007). The MBA is a slow and labor-intensive method with a turnaround time of two to three days. Alternative, more rapid chemical analyses have been developed, *e.g.,* an ELISA method (Naar *et al.,* 2002). However, although being evaluated, this method has not yet been approved for regulatory decision-making activities.

Shellfish can depurate toxins within two to six weeks after counts of *K. brevis* cells have returned to background levels in an area. However, there is one report that indicates the edible clam, *Chione cancellata,* retained toxicity for one year after exposure (Steidinger *et al.,* 1998). This suggests that under certain conditions, a reservoir of toxic biota may persist in bottom communities and prolong the risks to public health long after a red tide has dissipated. Research continues on brevetoxin retention times in different shellfish species (*e.g.,* Plakas *et al.,* 2002) and may require managers to update monitoring and regulatory activities and species-specific guidelines.

Over the past 40 years, cases of NSP in Florida have only occurred when shellfish were harvested illegally from state-regulated closed shellfish beds or unapproved areas (Steidinger *et al.,* 1998; Poli *et al.,* 2000; Heil, 2009). In 2006, for example, more than a dozen cases of NSP occurred in the Sanibel area when multiple clam species were recreationally harvested from unapproved areas adjacent to the beach area during or just after a red tide event (Terzagian, 2006; Watkins *et al.,* 2008). Florida continues to have cases of NSP associated with recreational harvesting from closed areas. Foreign and out-of-state tourists are particularly vulnerable because they have no knowledge of the permissible harvesting areas or the health risks associated with such activity. There is also a lack of awareness of local resources that provide information on red tide events along with shellfish harvesting guidelines and regulations.

AEROSOL

There is no specific proactive outreach mechanism to inform residents and visitors that a red tide is in an area and that the aerosol is a potential public health risk. In most instances, this information is picked up by local media outlets, such as television, newspapers, and radio, although some counties are implementing proactive measures. MML and counties such as Collier, Lee, Manatee, Pinellas, and Sarasota have implemented a real-time Beach Condition Reporting System. Beach conditions, including water color, chance of respiratory irritation, and presence of dead fish are reported twice daily at various beach sites. Reports can be accessed by the public directly via a hotline (941-BEACHES) or at http://coolgate.mote.org/beachconditions/. Because blooms, once onshore, can be extremely variable, this system allows beach goers to make informed decisions on which beach to visit to experience minimal exposure to toxins. People can also log onto various other Web sites, such as FWRI's http://research.MyFWC.com/, or call the FDOH Aquatic Toxins Hotline (1-888-232-8635) for more information on bloom conditions.

These sources are usually adequate for local residents who are keeping informed. Tourists, especially those who are only visiting for a few days or those for whom English is not their primary language, are a much harder audience to reach. Ideally, residents and tourists are made aware that a red tide that has come inshore and is present along the beach or in near shore coastal waters and that people with asthma and other respiratory problems should avoid certain areas. Unfortunately, conditions that favor dispersal of the respiratory irritant, such as onshore winds, can change dramatically and shift direction within hours. Since the toxins are associated with marine particulates, exposure can be reduced by use of a particle mask commonly available in hardware or drug stores. Antihistamines are also somewhat effective for reducing the effects; however, this over-the-counter medication should be taken only following labeled directions and/or on the advice of a physician.

FISH

No monitoring or regulatory programs exist for fish exposed to brevetoxins. Although fish can concentrate brevetoxins in their viscera, levels in the fillet of live-caught fish have not suggested a human health risk.

Saxitoxin, Puffer Fish Poisoning, and Saxitoxin Puffer Fish Poisoning

Background

Poisoning from consumption of puffer fish (also known as "blowfish") is usually associated with tetrodotoxin

(TTX) found in fish viscera. These poisonings are more common in Asia and are associated with the cultural practice of eating puffer fish (fugu) prepared by specially trained chefs as a delicacy. In the U.S.A., PFP has usually been associated with imported puffer fish (Marcus *et al.,* 2002); fatalities have rarely occurred after the consumption of indigenous puffer fish. However, in Hawaii, white-spotted puffer fish, *Arothron hispidus,* were implicated in seven deaths (Ahmed, 1991). Until 1974, only seven PFP cases caused by the consumption of locally caught "blowfish" or puffer fish had been documented in Florida (Benson, 1956; Hemmert, 1974; Mosher and Fuhrmann, 1984; Ahmed, 1991; Bigler, 1999). These cases included three fatalities, one of which was a woman who died 45 minutes after consuming the toxic liver of a checkered puffer fish (*Sphoeroides testudineus*) (Benson, 1956). The toxins involved in the previous Florida PFP cases were not characterized, but because PFP is usually associated with TTX, investigators likely assumed that TTX was the cause (Benson, 1956; Hemmert, 1974; Bigler, 1999). Tissues from Florida bandtail (*S. spengleri*), checkered, and southern (*S. nephelus*) puffer fish were found to be lethal in MBA (Lalone *et al.,* 1963; Burklew and Morton, 1971), but again, the specific toxins were not determined. (Note: MBA is a nonspecific test that only assesses lethality of the tissue composite and does not identify the causative agent, toxin, or group of toxins.)

From January 2002 to May 2004, 28 cases of poisoning from puffer fish in Florida, New Jersey, Virginia, and New York were linked to fish originating from the Indian River Lagoon (IRL) in Florida (Bodager, 2002; Landsberg *et al.,* 2006). In a 1960s toxicity study, extracts of tissues from IRL southern puffer fish were demonstrated to be toxic to mice by intraperitoneal injection (Lalone *et al.,* 1963). Muscle tissue was the most lethal to mice, as it is currently. However, the toxins in these puffer fish samples were not characterized. Although this anecdotal evidence suggests that southern puffer fish may have been mildly toxic from STXs in the IRL for the past 45 years, there has been no indication that toxin levels over that period were similar to those observed since 2002; no fish poisoning incidents were reported or documented from this area prior to 2002. Initial analyses of toxins from unidentified puffer fish fillet remnants from one of the early 2002 poisoning cases in New Jersey revealed STXs (Quilliam *et al.,* 2004), not TTXs, a distinction that could not be made solely on the basis of consumer symptoms or traditional screening methods (*i.e.,* MBA). This was the first time that STX had been associated with puffer fish poisonings in the USA.

The sudden appearance of STXs at potentially lethal concentrations in an area previously not known to have such toxins signaled an unprecedented and emerging public health threat and natural-resource challenge for Florida. STX is a complex molecule that interferes with the voltage-sensitive sodium (Na^+) channel in neuron membranes. STXs can selectively bind to neural cell Na^+ channels blocking these molecules from entering or exiting the cell. Lack of Na^+ inside the cell blocks its action potential, inhibiting transmission of neural impulses and resulting in impairment of bodily functions. Globally, STXs are usually associated with paralytic shellfish poisoning (PSP), an acute intoxication occurring in humans after the consumption of toxic shellfish, such filter-feeding shellfish consume microalgae and retain STXs in their tissue. Human consumption of these shellfish can cause severe and potentially lethal cases of PSP.

Because STXs had never been identified in Florida's marine waters and their distribution and origin were unknown, an intensive survey of biota in the IRL was initiated in April 2002 to determine the concentration and distribution of this toxin (Landsberg *et al.,* 2006). Puffer fish were confirmed as a hazardous reservoir of STXs in Florida's marine waters, with the dinoflagellate *Pyrodinium bahamense* implicated as the putative toxin source. STXs were confirmed in IRL southern, checkered, and bandtail puffer fish, with toxins detected in skin, muscle, and viscera in concentrations of up to 20,106 µg STX eq./100 g tissue in muscle (the Food and Drug Administration [FDA] action level for STX in edible tissue is 80 µg STX eq./100 g) (Wekell *et al.,* 2004; Abbott *et al.,* 2009). TTX has also been found in IRL puffer fish, but compared to STX, nearly all southern puffer tissues tested had only trace amounts of TTX. Both checkered and bandtail puffers from the central and southern IRL had higher concentrations of TTX than of STX in all tissues, checkered puffer livers being the most toxic (Deeds *et al.,* 2008). Regardless of toxin, puffer fish in the IRL are extremely dangerous to eat.

Pyrodinium bahamense represents an emerging public health threat in Florida; it has been associated with fatal PSP in the Pacific but was not known to be toxic in the western Atlantic. Human fatalities from STX produced by *P. bahamense* blooms have been documented globally (Rodrigue *et al.,* 1990). Landsberg *et al.* (2006) proposed characterizing this food poisoning syndrome as SPFP to distinguish it from PFP traditionally associated with TTX and from PSP caused by STXs in shellfish (see Appendix B, Medical Fact Sheets and Case Definitions). As of January 2009, there have been no cases of PSP in Florida.

Ecology

STXs and PSP associated with *Pyrodinium bahamense* are best known from the tropical and subtropical waters of the Pacific (*e.g.,* Malaysia, the Philippines, and Papua New Guinea). Toxic strains are also known from Pacific waters off Central America where blooms have been associated with PSP in shellfish (Vargas-Montero and Freer, 2004).

Blooms of *Pyrodinium bahamense* are now common in the IRL and have been documented for several years (Badylak *et al.,* 2004; Phlips *et al.,* 2004), but until the outbreaks of SPFP in 2002, there was no indication that this variety was toxic (Landsberg *et al.,* 2006). Puffer fish can retain the toxin for months and even years and therefore may be toxic even when a *Pyrodinium* bloom is not present. *Pyrodinium* in Florida is *P. bahamense* var. *bahamense,* and it produces STX. Prior to the 2002 event, all Atlantic *Pyrodinium* (*i.e., P. bahamense* var. *bahamense*) were thought to be non-toxic and only *P. bahamense* var. *compressum,* which occurs in the Pacific, were thought to produce STX and its derivatives (Badylak *et al.,* 2004; Phlips *et al.,* 2004; Landsberg *et al.,* 2006). In this report, both varieties will be referred to as *P. bahamense.*

Effects on Human Health

Because they are immune to STXs, puffer fish can accumulate high toxin concentrations in the muscle tissue, making them a significant threat to consumers. The extreme toxicity of these puffer fish fillets, well above the FDA action level, emphasizes the public health danger posed by these fish and supports the permanent ban on their harvest in the IRL (Landsberg *et al.,* 2006; Abbott *et al.,* 2009).

Symptoms of SPFP may include tingling or numbness in the mouth and/or lips, paresthesia in the face and/or extremities, ataxia, nausea, vomiting, drowsiness, incoherent speech, and muscle weakness (Hammond *et al.,* 2002; Quilliam *et al.,* 2004). In severe cases, respiratory paralysis and death may occur. STX is heat- and acid-stable and is not detoxified or destroyed by freezing or cooking. The onset of symptoms is usually rapid as soon as 30 minutes to 2 hours after ingestion, to as long as 8 hours. The duration of illness may range from 12 hours to, in severe cases, 45 days. In the Florida cases, almost half of the victims required emergency room services and nearly half of those individuals required hospital admission. Long term neurologic effects have not been studied (see Appendix B, Medical Fact Sheets and Case Definitions).

Effects on Living Resources

In addition to their effects on human health, STXs are responsible for aquatic animal mortalities (Landsberg, 2002; Shumway *et al.,* 2003; Van Dolah *et al.,* 2003; Landsberg *et al.,* 2005). Marine mammals are exposed to STXs primarily through their diet, consuming toxins vectored through the food chain. For example, during a five-week period beginning in late November 1987, 14 humpback whales, *Megaptera novaeangliae,* died in New England after ingesting Atlantic mackerel, *Scomber scombrus,* containing STXs. STXs were present in the viscera, especially the liver, of mackerel caught where the whales had been feeding. Extracts of whale kidney, liver, and stomach contents were lethal to mice by standard bioassay, and the mice showed classic signs of STX poisoning (Geraci *et al.,* 1989). STXs were a key suspect in the mortality of more than 100 highly endangered Mediterranean monk seals, *Monachus monachus,* on the coast of West Africa during May and June 1997 (Reyero *et al.,* 1999). During a *Pyrodinium* bloom in the Far East, mortalities of dolphins and other animals were reported (Maclean and White, 1985), but no follow-up investigation was conducted. In conjunction with several PSP incidents in Central America in 2006, fish kills and dead turtles were associated with *P. bahamense* blooms (Licea-Duran *et al.,* 2008; Flewelling and Landsberg, FWC–FWRI, unpublished data).

In the past few years, the northern IRL has experienced a number of unusual events: dolphin, manatee, fish, and horseshoe crab mortalities; increased tumor incidence in hard clams (*Mercenaria* spp.); diseased shrimp; and both reductions in the natural recruitment of hard clams and increases in hatchery losses of these commercially important species (Bossart *et al.,* 2003; Landsberg and Kiryu, 2005; Landsberg *et al.,* 2006). However, to what extent, if at all, these events are linked to the emerging issue of toxic *P. bahamense* blooms and STXs in the IRL remains undetermined.

Economic Effects

There has been little assessment of the economic effects of STXs in the IRL. However, puffer fish are not considered to be a significant recreational or commercial resource, and there has been minimal feedback from the public indicating any adverse economic effects. The puffer fish ban does not appear to have had any significant effect on the tourist and sport fishing industries. Potential impacts on the hard clam industry are possible. Highly lethal STXs have the potential to have significant economic effects on fishery industries and to threaten marine mammals, birds, and other aquatic organisms.

Existing Monitoring Operations

In Florida's marine waters, STXs have only been associated with *P. bahamense,* extensive blooms of which appeared in the IRL in 2002. During 2002–2004, all the

Florida SPFP cases were linked to puffer fish originating from the northern Indian River and the Banana River on Florida's east coast. All the puffer fish were caught recreationally, except for one case in which puffer fish were commercially harvested and reached a New Jersey fish market (Bodager, 2002).With the advent of the Florida SPFP cases, state (FDOH, FDACS) and federal (FDA, CDC) officials issued health advisories on 15 April 2002, and the FWC placed a ban on puffer fish harvesting in the IRL that remains in effect today. Funded by the CDC, FDOH, and NOAA, the FWC initiated an intensive statewide monitoring program to determine concentrations of STXs in various puffer fish species and in other biota, including shellfish. Puffer fish regularly monitored for toxicity include striped burrfish together with bandtail, checkered, and southern puffer fish. *Pyrodinium bahamense* concentrations are determined from monthly water samples at fixed stations throughout the IRL, funded by SJRWMD, FWC, and FDACS.

The FDACS and the FWC–FWRI are monitoring target shellfish species, particularly hard clams, *Mercenaria* spp., in the IRL because bioaccumulation of STXs in shellfish can pose a risk to consumers.The FDA has established national regulatory standards for acceptable limits of STXs in seafood. In Florida, only puffer fish have consistently exceeded the limit for acceptable STX levels of 80 µg STX eq./100 g, data that support continuation of the puffer-fishing ban in the IRL (Abbott *et al.,* 2009). Samples of hard clams are collected monthly by FDACS throughout the IRL. Clam tissues are tested for toxicity by FWC–FWRI using the MBA. If warranted, FDACS implements shellfish bed closures and posts this information on their Web site http://www.floridaaquaculture.com/seas/seas_statusmap.htm. Shellfish beds in the northern IRL have been closed on a few occasions (2003, 2005) as a precautionary measure when toxin levels in bivalves as determined by MBA minimally exceeded the FDA action limit. In 2006, shellfish beds were closed by FDACS for more extensive periods during the summer and fall when *P. bahamense* blooms extended throughout the IRL and persisted.

Ciguatoxin and Ciguatera Fish Poisoning

Background

Possibly the oldest report of seafood intoxication in the Americas was made by Peter Martyr (1457–1526) in the West Indies (Halstead, 1967). An illness now known as CFP was first noted (Gruder, 1930) and later recorded in the 1600s and 1700s (Withers, 1982). In the early 1800s, a Cuban ichthyologist described an ordinance prohibiting the sale of ciguatera-contaminated fish weighing more than three pounds. He noted that in the Caribbean, toxic fish were unevenly distributed: fish on one side of an island were toxic while those on the other side were nontoxic (Gordon, 1977).The origin or causative agent was unknown.The organism that causes ciguatera was eventually identified as *Gambierdiscus toxicus* (Yasumoto *et al.,* 1977; Adachi and Fukuyo, 1979), a toxic dinoflagellate that normally inhabits reefs and seaweeds in subtropical and tropical regions. Several other toxic *Gambierdiscus* species have now been described (Holmes, 1998; Chinain *et al.,* 1999). CFP has continued to occur and is prevalent in subtropical and tropical regions, including the Indo-Pacific, Hawaiian Islands, and Caribbean Sea.

Randall (1958) first suggested that the toxin, ciguatoxin, is accumulated through the food chain into the top predators including large, reef-dwelling piscivorous fish such as grouper. Ciguatoxins are lipid-soluble molecules that are absorbed directly in the viscera and accumulate in muscle tissue either intact or with some biochemical modification. Ciguatoxins are often changed biochemically as they are transmitted up the food chain, resulting in a variable complex of ciguatoxins in herbivorous fish. Because the top-level carnivorous fish may have consumed a variety of herbivorous fish species over their lifetime, the complex of ciguatoxins that have been biotransformed, bioaccumulated, and deposited in the muscle of a fish may be present in different proportions and combinations. Only a few of the toxins have been identified or characterized from ciguateric fish. However, more than 20 precursor gambiertoxins and ciguatoxins have been identified from the algae *G. toxicus* and from herbivorous and carnivorous fish tissue (Lehane and Lewis, 2000). Evidence also suggests that when reef fish become toxic, they can remain so for a long period of time either because of the slow depuration of the acquired toxin or from continued exposure to more ciguatoxins. Because many of these fish are permanent reef dwellers, they remain exposed to sources of toxin (Banner *et al.,* 1966).

Ecology

Ciguatera outbreaks are sometimes associated with reef disturbances from hurricanes such as Andrew and Gilbert (Bohnsack *et al.,* 1994), coral bleaching (Kohler and Kohler, 1992), dredging (Bagnis *et al.,* 1990; Tebana, 1992), use of destructive methods such as rotenone and dynamite for the commercial harvesting of fish or corals, and by other anthropogenic alterations (South Pacific

Commission, 1990). However, when boat channels were blasted from coral, existing populations of *G. toxicus* increased, but the species did not appear in the newly exposed areas (Kaly and Jones, 1994). Increases in *G. toxicus* populations can also accompany an increased abundance of macroalgae, particularly filamentous red algae (Bomber *et al.,* 1989; Lehane and Lewis, 2000). Several other species of *Gambierdiscus* in Florida are being described (Litaker, unpublished data).

There are only a limited number of places in the continental United States where indigenous ciguatera phytoplankton species are found (either on algal substrates or on reefs) and where verified toxicities have been confirmed in local fish. In Florida, these include the Florida Keys, Florida Bay, the Dry Tortugas, and the Tortugas Banks; and in Texas, the Flower Gardens (Bomber *et al.,* 1989; de Sylva, 1994). Confirmed ciguatera cases in Texas were associated with fish captured near an oil platform 30 miles from Matagorda. Oil platforms and their attached flora may provide good substrate for colonization by *G. toxicus* and other ciguateric dinoflagellates (Villareal *et al.,* 2006).

Since the 1980s, there have finally been major advances and intensive chemical studies of the organisms and toxins causing this illness. Although other toxic dinoflagellates (*e.g., Prorocentrum, Ostreopsis*) have been suspected in CFP, *Gambierdiscus* is the only genus that has been definitively implicated (Lewis and Holmes, 1993). Ciguatoxins originating from *G. toxicus* are concentrated up the food chain from primary consumers that have been exposed to *Gambierdiscus* cells or toxins through herbivorous fish that browse on affected substrates to finally accumulate in the muscles of the carnivorous fish at the top of the food-chain. As the toxin concentration in these fish increases, they pose a risk to human consumers (Lewis and Holmes, 1993; Swift and Swift, 1993). At least 400 fish species have been implicated in CFP (Halstead, 1967), the most common being tropical fish such as groupers, barracudas, hogfish, snappers, jacks, triggerfish, kingfish, parrotfish, and surgeonfish (Backer *et al.,* 2003a).

Effects on Human Health

In humans, consumption of ciguatoxic herbivorous fish is usually associated with gastrointestinal illness or neurological symptoms, whereas toxic carnivorous fish are more often associated with cardiovascular and neurological disorders (Bagnis, 1968). Symptoms begin 1 to 12 hours after ingestion of contaminated fish and include sensory disturbances such as paresthesias, arthralgia, myalgia, diarrhea, asthenia, chills, headache, nausea, pruritus, abdominal pain, vomiting, perspiration, tearing, and giddiness (Swift and Swift, 1993; Backer *et al.,* 2003a) (see Appendix B, Medical Fact Sheets and Case Definitions). Gastrointestinal symptoms usually persist for only a few days, whereas neurological symptoms may persist for several months or years. In the Pacific, for example, chronic neurological symptoms have been reported to last for up to 25 years after the initial exposure (Backer *et al.,* 2003a). Extreme cases, which are rare, result in paralysis, loss of consciousness, and death. In sublethal cases, symptoms may continue for weeks to months until the acute phase abates. In some instances, symptoms have continued or recurred years later. Ingestion of fish or alcohol may cause symptoms to recur long after the original intoxication event. Administering intravenous mannitol within 24 hours of intoxication has helped to reduce brain swelling and diminish the most irritating symptoms (Palafox *et al.,* 1988; Blythe *et al.,* 1994). No permanent cure is currently available.

Ciguatoxins are not affected by cooking or freezing and can currently be confirmed only by specific chemical analyses exclusively available through the FDA. Toxin identification by chemical analysis is challenging because pure ciguatoxin is not available for comparison and because human illness can be caused by low concentrations of toxins in fish muscle. The broad suite of ciguatoxins contributes to the wide variety of symptoms and effects on humans diagnosed with CFP. The presence of different groupings of ciguatoxins in ciguateric fish from the Caribbean Sea and the Pacific Ocean probably underlies the clinical differences in the ciguatera syndrome as reported in the two regions (Vernoux and Lewis, 1997).

More than 175 symptoms of CFP have been reported (Swift and Swift, 1993). CFP probably also includes several other reported food-poisoning syndromes associated with different toxins originating from microalgae. Scaritoxin, a lipid-soluble toxin from parrotfish, and maitotoxin, a water-soluble toxin from surgeonfish, have also been associated with CFP. Palytoxin has been implicated in ciguatera-like symptoms in humans who ate smoked mackerel (*Decapterus macrosoma*) (Kodama *et al.,* 1989). Both lipid- and water-soluble compounds interfere with neural conduction by acting on either the calcium or the sodium channel (Baden *et al.,* 1990).

Ciguatoxic barracuda have been found off Florida's west coast (Morton and Burklew, 1970; Tomas, 1996) and the Florida Keys, including the Dry Tortugas (Tomas and Baden, unpublished data). In the late 1970s, the threat of ciguatera caused the prohibition of barracuda sales in Miami, Florida (Lawrence *et al.,* 1980). During the late 1980s, ciguatera intoxications on the east and west coasts of Florida caused further alarm. The frequency and extent of these intoxications and the species of ciguatoxic fish involved were documented by de Sylva (1994).

In Florida, ciguatera is a larger public health risk than NSP (McKee *et al.,* 2001). Worldwide, an estimated 50,000 victims suffer from CFP each year, and some estimate 1,300 cases per annum occur in Florida alone (de Sylva, 1994). The gross underreporting of ciguatera to the FDOH stems from several problems: mild subclinical cases that do not reach health-care providers, misdiagnosis, difficulty in diagnosis and case confirmation, and failure by treating physicians to make a report (despite the fact the ciguatera is a reportable disease in Florida) (Freidman *et al.,* 2008). The FDOH reportable-disease network, Merlin®, indicates that there were 4 reported, confirmed cases in 2005 and 16 in 2006. However, the FDOH notes that the number of ciguatera outbreak-related cases in 2005 and 2006 were 8 and 44, respectively, and in 2007 and 2008, 34 and 51 were reported.

Twenty cases of CFP from consumption of amberjack were reported to FDOH during August and September 1991 (Hammond *et al.,* 1993). Eight persons developed one or more of the following symptoms: cramps, nausea, vomiting, diarrhea, or chills and sweats, all within 3–9 hours after eating amberjack at a restaurant on August 7 or 8. Symptoms lasted 12 to 24 hours after onset; three persons were hospitalized. By August 12, patients began to report pruritus of hands and feet, paresthesia, dysesthesia, and muscle weakness. Based on the initial food histories, amberjack was suspected as the source of illness. On August 14, three additional persons with similar symptoms were identified; they had also eaten amberjack at the same restaurant. Because of the unique symptomatology and the common denominator of amberjack consumption, investigators suspected either scombroid or ciguatera poisoning. The shipment of amberjack was traced to a seafood dealer in Key West, Florida, who had distributed the fish through a dealer in north Florida. The second dealer subsequently had sold the fish to the restaurant in question, another restaurant in Alabama, and to a third dealer who sold the fish to two grocery stores, one in Alabama and the other in north Florida. The FDOH received reports of additional suspected cases of CFP among persons who had bought amberjack at the Alabama grocery store (six persons) and at the north Florida grocery store (three). The FDA evaluated 19 amberjack samples believed to have originated from a single lot from the Key West dealer and obtained samples from the restaurants and grocery stores in Florida and Alabama. Forty percent of the specimens tested by MBA were positive for ciguatera-related biotoxins. This outbreak highlights some of the difficulties in tracing suspected fish, case identification, and the numerous vendors and agencies that must be involved in a successful investigation.

It might be expected that CFP events would become more common if there are increased levels of ciguatoxins in the environment. However, not all of these events may be identified because (1) sale of barracuda, the most common source of affected commercial fish, is prohibited in Miami; (2) many, if not most, ciguatera cases go unreported; (3) it is difficult to determine the source of ciguatera toxicity in fish; and (4) CFP is difficult to diagnosis after the first few days of illness because conflicting diagnoses must be eliminated and a complete food history obtained before ciguatera can be confirmed (Lawrence *et al.,* 1980; de Sylva, 1994; Freidman *et al.,* 2008).

Effects on Living Resources

Although ciguatoxins have not been reported to have any acute effect on fish in the wild (Banner *et al.,* 1966; Swift and Swift, 1993; Naar *et al.,* 2007), experiments have shown that ciguatoxins can be lethal to fish when dissolved in aquarium water or when administered either orally or by intraperitoneal injection (Davin *et al.,* 1986, 1988; Lewis, 1992). Experimentally exposed fish behave abnormally, exhibiting erratic movement, disorientation, inactivity, and loss of equilibrium; signs of physiological distress include blanching or darkening of the skin, changes in opercular movement patterns, and loss of appetite (Kelly *et al.,* 1992; Lewis, 1992). In 1993 through 1994 ciguatoxins were thought to play a role in the large-scale die-off of tropical fish in Florida and the Caribbean (Landsberg, 1995).

Because ciguatoxins can be highly toxic and lethal to fish, Lewis (1992) suggested that there may be an upper limit to tissue concentrations of ciguatoxin that fish can tolerate. Fish can retain these toxins for long periods of time; toxic fish remained so for up to 30 months, even when maintained in nontoxic water and fed nontoxic diets (Banner *et al.,* 1966). A die-off of severely affected fish could contribute to the low incidence of human fatalities associated with CFP. To date, there is minimal but compelling evidence that ciguatoxins can affect fish health and under certain circumstances, may be responsible for fish mortalities (Landsberg, 1995).

Economic Effects

Because ciguatera cases are underreported by up to 90%, it is difficult to make accurate estimates of the economic effects on Florida's economy (Fleming *et al.,* 1998; McKee *et al.,* 2001). These effects include not only lost tourism revenue, restaurant liabilities, treatment 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

FWC image

Florida red tide fish kill investigation, Venice Airport Beach, October 1959, Agent M. P. Courtney, Florida State Board of Conservation.

toxic, particularly those of *Chattonella* and *Prymnesium.*

Many fish kills, particularly those occuring in the early-morning hours, are due to low dissolved oxygen levels in the water associated with algal blooms and are not necessarily the result of toxins. During the day, photosynthetic activity of phytoplankton and other aquatic plants produces net oxygen. At night, in the dark, plants use oxygen and this can decrease the levels of dissolved oxygen in restricted systems.

The FWC responds to discolored water, fish kills, and other mortality or disease events to determine whether the cause is environmental or anthropogenic. A statewide fish kill hotline (1-800-636-0511) has been in operation for more than a decade. Access to the fish kill database, which contains information on fish kills in Florida reported to the FWC from 1972 to the present, is available on the internet at http://research.myfwc.com/fishkill/. New fish-kill reports can also be submitted through the Web site.

Pfiesteria *and* Pfiesteria*-Like Species*

In the late 1980s and early 1990s, small benthic dinoflagellates were discovered in fish aquaria and in North Carolina rivers and estuaries. These organisms were blamed for numerous fish kills that had been previously attributed to low dissolved oxygen (Noga *et al.*, 1993; Burkholder *et al.*, 1995, 1999, 2001; Burkholder and Glasgow, 1997). These dinoflagellates were unlike some other HAB species in that they were not photosynthetic; they were heterotrophic and preyed upon other microalgae as a food source. *Pfiesteria* could also feed on the epidermis of fish. *Pfiesteria piscicida* and *Pseudopfiesteria shumwayae* (previously *Pfiesteria shumwayae*) (Litaker *et al.*, 2005; Marshall *et al.*, 2006) were considered responsible for a large number of fish kills in North Carolina, and were thought to pose public health risks (Noga *et al.*, 1993; Burkholder *et al.*, 1995, 1999, 2001; Burkholder and Glasgow, 1997). Other *Pfi-*

esteria-like dinoflagellates (*e.g., Cryptoperidiniopsis brodyi* and *Luciella* spp.) have also been characterized and described based on morphology and genetics (Steidinger *et al.,* 2001, 2006; Mason *et al.,* 2007), but their potential threats to human health appear to be negligible.

The toxic mechanism for *P. shumwayae* activity has been proposed (Moeller *et al.,* 2007) after a decade of concerted research efforts to elucidate the production of bioactive compounds. Although the compounds are ichthyotoxic, it is still unclear whether this group of dinoflagellates pose a public health threat. Mortality of fish in tanks with *Pfiesteria* or *Pseudopfiesteria* is in part due to micropredation on fish epidermal cells by the heterotrophic dinoflagellates (Vogelbein *et al.,* 2001). Definitive studies have shown that fish ulcers and ulcerative mycosis (UM), once attributed by some researchers to *Pfiesteria* and related dinoflagellates, are caused instead by a primary pathogenic fungal oomycete, *Aphanomyces invadans* (Blazer *et al.*, 1999, 2002; Vogelbein *et al.,* 2001; Kiryu *et al.,* 2003; Sosa *et al.,* 2007a,b) found in fresh water and low-salinity areas.

Although *Pfiesteria* were considered to represent a risk to public health (Glasgow *et al.,* 1995; Grattan *et al.,* 1998; Haselow *et al.,* 2001; Morris, 2001), a study by Morris *et al.* (2006) concluded that repetitive low-level exposure to waters where *Pfiesteria* and *Pseudopfiesteria* have been found does not present a significant human health risk through occupational exposure to such estuarine environments. The identification of areas with *Pfiesteria* and *Pseudopfiesteria* was done by PCR analyses of over 3,500 water samples. The authors did not rule out the possiblity that outbreaks resulting from high level concentrations of these species could affect public health. Place *et al.* (2008) reviewed the history and current status of *Pfiesteria piscicida* and its natural resource and human health effects in mid-Atlantic state waters. They discussed several controversial topics: fish death through physical contact with *Pfiesteria* cells, the implications of a life cycle without many stages, fish biotoxicity assays with differing results, and the use of various detection techniques. More importantly they presented evidence that a co-occurring ichthyotoxic dinoflagellate, *Karlodinium veneficum,* produces known water-soluble toxins that have been isolated and characterized. These toxins were detected in *K. veneficum* cultures as well as at the sites of fish kills, raising the question, how many of the mid-Atlantic and Carolinean fish kills were actually caused by *Karlodinium* rather than *Pfiesteria? Pfiesteria piscicida, Pseudopfiesteria shumwayae,* and *Karlodinium* also co-occur in Florida waters. Public health risks from these genera are considered minimal.

In surveys conducted by FWC, low and essentially benign concentrations of *Pfiesteria piscicida* and *Pseudopfiesteria shumwayae* were found in less than 4% of Florida sites statewide, with no evidence of *Pfiesteria*-associated fish kills or disease problems. No recorded blooms of these species or the closely related *Pfiesteria*-like genera (Landsberg *et al.,* FWC–FWRI, unpublished data) have been reported in Florida. *Aphanomyces invadans* has been confirmed in more than eight species of estuarine fish with UM in Florida's waters (Sosa *et al.,* 2007a,b). Although associated with skin ulcers in estuarine fish, the fungus *A. invadans* does not present a public health risk.

Chapter 2
Agency Responsibility Matrices

Purpose *To identify federal, state, and local agencies with authority over, and responsibility for, response to harmful algal blooms and to facilitate their communication and coordination.*

The following charts present federal, state, and local governmental authority over and responsibility for response activities related to harmful algal blooms. These charts should help clarify the appropriate collaboration and coordination between these entities. In addition to the agencies shown here, interaction with academia, the public, and nongovernmental organizations such as veterinarians and rehabilitation centers ensures a comprehensive and integrated research effort.

Aquatic Animal Mortality Responsibility and/or Authority

Agency*	Aquatic Animal Mortality Illness/Disease Reporting	Aquatic Animal Mortality Illness/Disease Investigations	Aquatic Animal Mortality Monitoring	Contacts
NOAA	Xa,d	Xa,d	Xa,d	NMFS: Melody Baran, Blair Mase, Teri Rowles, Barbara Schroeder
USFWS	X	X	X	North Florida Field Office: Jim Valade
USDA	X	X	X	APHIS: Kathleen Hartman
USGS	X	X	X	National Wildlife Health Center: Anne Ballmann
FDOH	Xb	Xb	Xb	Division of Environmental Health: Carina Blackmore, Andrew Reich, Sharon Watkins, Danielle Stanek
FDACS	X	X	X	Kissimmee Animal Diagnostic Laboratory (KADL), Live Oak Laboratory
FWC	Xa,b, c,d,e	Xa,b, c,d,e	Xa,b, c,d,e	Fish and Wildlife Research Institute: Xa: Leslie Ward Xb: Mark Cunningham, Dan Wolf Xa,c,e: Jan Landsberg, Theresa Cody, Yasu Kiryu Xd: Allen Foley
PCC			X	Miami PCC and Aquatic Toxins Hotline: Richard Weisman Jacksonville PCC: Jay Schauben Tampa PCC: Cynthia Lewis-Younger
CHD	Xb	Xb	Xb	Epidemiology Programs Environmental Health Programs County specific, http://www.doh.state.fl.us/chdsitelist.htm
County Environmental Agency				County specific, must be identified locally
County Emergency Response Agency				http://floridadisaster.org

* Agencies are listed in descending order: federal, state, local.
a: marine mammals; b: birds, rabies-associated mammals; c: fish kills; d: turtles; e: invertebrates (*e.g.,* crustacea, mollusks)

Environmental Sampling Responsibility and/or Authority

Agency*	Fresh-water	Brackish Water	Marine Water	Analytical Support	Contacts
CDC	X				Health Studies Branch: Lorraine Backer
FDA			X	X	Office of Seafood Safety and Nutrition: Stacey Etheridge, Jon Deeds
EPA	X	X			National Health and Environmental Effects Research Laboratory, Neurotoxicology Division Region 4: Ed Decker
NEP		X	X		Charlotte Harbor NEP: Lisa Beever IRL NEP: Troy Rice Tampa Bay NEP: Holly Greening Sarasota Bay Project: Mark Alderson
NOAA		X	X	X	Biotoxin Program, Charleston Laboratory: Tod Leighfield, Fran Van Dolah Pacific Northwest Laboratory: Vera Trainer
USDA	X	X			Terence Evens
USFWS	X	X	X		Todd Hopkins, Dawn Jennings
USGS	X	X	X		Barry Rosen
FDOH	Xa,b,c	Xa,c	Xa	X	Division of Environmental Health: Andrew Reich, Sharon Watkins Bureau of Water Programs, Healthy Beaches Monitoring: Bob Vincent, David Polk Bureau of Laboratories: Ming Chan, Dean Willis
FDEP	Xb, e,f	Xb, e,f		X	Division of Water: Russ Frydenborg Laboratory Services: David Whiting, Tim Fitzpatrick,
FDACS			Xe	X	Palm Bay Office: Howard Beadle Tallahassee Office: Chris Brooks, David Heil, Alan Pierce
FWC	Xc	Xc, d,f	Xc,d, e,f	X	Harmful Algal Blooms: Cindy Heil, Leanne Flewelling Fish and Wildlife Health: Jan Landsberg
WMD	Xb, e,f	Xb, e,f			SFWMD: Richard Pfeuffer SJRWMD: Dean Campbell, John Hendrickson SWFWMD: Veronica Craw Suwannee WMD: Robbie McKinney NWFWMD: Graham Lewis
PCC					Miami PCC and Aquatic Toxins Hotline: Richard Weisman Jacksonville PCC: Jay Schauben Tampa PCC: Cynthia Lewis-Younger
CHD	Xa,b,c	Xa,c	Xa	X	County-specific, http://www.doh.state.fl.us/chdsitelist.htm
County Environmental Agencies					County-specific, must be identified locally
County Emergency Response Agency					http://floridadisaster.org
Primary Care Facilities					http://www.floridahealthfinder.gov/

* Agencies are listed in descending order: federal, state, local.
a: microbiology; b: inorganic and organic parameters; c: cyanotoxins; d: marine toxins; e: cell counts; f: identification

Shellfish Responsibility and/or Authority

Agency*	Shellfish Regulation	Shellfish Bed Permitting	Shellfish Retail Sales Inspection	Shellfish Bed Monitoring	Laboratory Support (based on capabilities/ capacity)	Contacts
FDA	X				X	Dauphin Island Laboratory: Robert Dickey Office of Seafood Safety Laboratory: Sherwood Hall, Stacey Etheridge, Jon Deeds
FDOH			X		X	Division of Environmental Health: Carina Blackmore, Sharon Watkins, Roberta Hammond, Regional Environmental Epidemiologists
FDACS	X	X	X	X	X	Aquaculture Program: David Heil, Chris Brooks Bureau of Food Safety: John Fruin
FWC				X	X	Harmful Algal Blooms: Leanne Flewelling Fish and Wildlife Health: Jan Landsberg Molluscan Fisheries: Steve Geiger
CHD						County-specific, http://www.doh.state.fl.us/chdsitelist.htm
County Environmental Agency						County specific, must be identified locally
County Emergency Response Agency						http://floridadisaster.org

* Agencies are listed in descending order: federal, state, local.

Human Surveillance Responsibility and/or Authority

Agency*	Human Morbidity and/or Mortality Reporting	Human Morbidity and/or Mortality Investigations	Human Morbidity and/or Mortality Monitoring	Contacts
CDC	X	X	X	Health Studies Branch: Lorraine Backer
USAMRIID				Mark Poli
FDA		X		Dauphin Island Laboratory: Robert Dickey Office of Seafood Safety: Sherwood Hall, Jon Deeds, Stacey Etheridge
FDOH	X	X	X	Epidemiology Program: Julia Gill Division of Environmental Health: Roberta Hammond, Carina Blackmore, Andrew Reich, Sharon Watkins
FWC		X		Division of Law Enforcement: Col. Julie Jones
PCC	X		X	Miami PCC: Richard Weisman, Eva Jerez Tampa PCC: Cynthia Lewis-Younger, MD Jacksonville PCC: Jay Schauben
CHD	X	X	X	County specific, http://www.doh.state.fl.us/chdsitelist.htm
County Environmental Agency				County specific, must be identified locally
County Emergency Response Agency				http://floridadisaster.org
Physicians	Xa			http://www.floridahealthfinder.gov/

* Agencies are listed in descending order: federal, state, local.
a: reportable disease

Chapter 3
Available Resources and Databases

Purpose *To identify existing resources and databases containing historic and present information for physiographic, environmental, animal, and human monitoring and surveillance.*

The following tables identify existing resources for physiographic, environmental monitoring, and both animal and human surveillance data. These tables can be used to identify historic trends within a region or to find accurate current information that may help identify the possible cause of an illness or outbreak, or determine a probable direction for further investigation. Timely and accurate information can be used by natural resource managers, researchers, public health officials, and legislators to respond to events that may be of urgent public-health consequence such as to design disease prevention and mitigation strategies; to address interconnections between human, domestic animal, and wildlife disease; and to assist in identification of "normal' disease issues versus biosecurity concerns.

Environmental Monitoring Data

Data Base	Source	Description	Region	Date	Web Link
Florida Lakewatch Program	UF/IFAS	Report of limnological data from 1,235 inland water bodies and river/creek stations and 269 saline stations	Statewide	1986–2001	http://lakewatch.ifas.ufl.edu/data2001.htm
Florida Lakewatch Program	UF/IFAS	Report of limnological data from 607 lakes, 127 river/creek stations, 4 springs, and 142 saline stations	Statewide	2004	http://lakewatch.ifas.ufl.edu/data2004.htm
Healthy Beaches	FDOH	Beach water sampling for enterococci and fecal coliform analysis	FL coastal counties	2001–current	http://esetappsdoh.doh.state.fl.us/irm00beachwater/default.aspx
HAB Events	FWC–FWRI	Results of *K. brevis* sampling activities	Gulf Coast	1954–current	http://ocean.floridamarine.org/mrgis/viewer.htm
Shellfish Harvesting Area Status	FDACS Division of Aquaculture	Open/Closed status of shellfish harvesting areas	Statewide	current	http://www.floridaaquaculture com/SEAS/seas_statusmap.htm
STORET Legacy Data Center	EPA Office of Water	Historical water quality data archives	National	up to 1998	http://www.epa.gov/storpubl/legacy/gateway.htm
STORET	FDEP/EPA Office of Water	Comprehensive repository of water quality and biological and physical data	National	1999–current	http://dep.state.fl.us/water/monitoring/data.htm http://www.epa.gov/storet/

Animal Surveillance Data

Data Base	Source	Description	Region	Date	Web Link
Bird Mortality	FWC	Access for reporting wild bird die-offs only	Statewide	2000–current	http://myfwc.com/bird/
Fish Kill	FWC–FWRI	Reported kills to FWRI identified by date, location, animal category, probable kill cause, water body, and specimen count	Statewide	1972–current	http://research.myfwc.com/fishkill/
Florida Lakewatch Program	UF/IFAS	Summary report of 35 lake sampling sites for age and abundance assessment of fish; includes comparative data of trophic status and aquatic macrophyte abundance	Statewide	1998–2003	http://lakewatch.ifas.ufl.edu/FishData2003.htm
FWVSS	FDOH	Manages data on food- and water-borne disease outbreaks related to complaints including geographic elements, vehicles of transmission, and implicated causes	Statewide	2004–current	http://florida.state.gegov.com/webadmin/login.cfm?attempt=index.cfm
Manatee Counts	FWC–FWRI	Synoptic count data of manatee population estimates from aerial surveys	Statewide	1991–2006	http://ocean.floridamarine.org/mrgis/viewer.htm
Manatee Mortality	FWC–FWRI	Historic records of manatee mortalities	Statewide	1974–2005	http://ocean.floridamarine.org/mrgis/viewer.htm
Turtle Nesting	FWC–FWRI	Distribution, seasonality, and abundance of nesting sea turtles	Statewide	2004–current	http://ocean.floridamarine.org/mrgis/viewer.htm
Turtle Strandings	FWC–FWRI	Records of turtle strandings to monitor marine turtle mortalities and identify mortality factors	Statewide	1980–2005	http://ocean.floridamarine.org/mrgis/viewer.htm
Wildlife Mortality	USGS	Documents wildlife mortality events including locations, species, and causes of death	National	1995–current	http://www.nwhc.usgs.gov/publications/quarterly_reports/

Human Surveillance Data

Data Base	Source	Description	Region	Date	Web Link
Asthma	AHCA	Summary of hospitalization and ER charges	Statewide		http://ahca.myflorida.com/Inside_AHCA/index.shtml
Emergency Room	AHCA	Summary of hospitalization and ER charges	Statewide		http://ahca.myflorida.com/Inside_AHCA/index.shtml
FDENS/ EpiCom	FDOH	Information system that supports 24 hrs a day, 365 days a year, notification and alert within the public health emergency response system	Statewide	2003–current	http://www.fdens.com Tutorial available at http://www.flhan.com/ or https://epicomfl.com/Attachments/FDENS_Tutorial.htm
FPIC Network	FPIC	Summary report of calls to FPIC including calls related to aquatic toxins	Nationwide, biased toward Florida	2002–current	http://www.fpicn.org/
FWVSS	FDOH	Manages data on food- and water-borne disease outbreaks related to complaints including geographic elements, vehicles of transmission, and implicated causes	Statewide	2004 current	http://florida.state.gegov.com/webadmin/login.cfm?attempt=index.cfm
HABISS	CDC	Collects data on human and animal health and on the environmental effects of HABs; modular format allows data collection to be expanded to suit the needs of state and local health and environmental protection agencies	Nationwide	2007–current	http://www.cdc.gov/hab/surveillance.htm#about
Merlin®	FDOH	Electronic communicable disease reporting system, access by FDOH approval only	Statewide		http://merlintraining.isf.com/MerlinNet/start/Login.aspx
OTC Drug Use	NRDM	Summary report of over-the-counter (OTC) drug sales by category	Nationwide, Florida well represented	2003–current	http://rods.health.pitt.edu/NRDM.htm

Physiographic Data

Data Base	Source	Description	Region	Date	Web Link
Florida Lakewatch Program	UF/IFAS	Bathymetric maps for all Florida lakes	Statewide	Current	http://lakewatch.ifas.ufl.edu/MapList.htm
Gulf of Mexico Bathymetry	FWC–FWRI	Depth contours of offshore areas of Gulf of Mexico, South Atlantic Bight, and northern Caribbean; see NOAA Nautical Chart 411	Gulf of Mexico	1997–current	http://ocean.floridamarine.org/mrgis/viewer.htm
Nearshore Bathymetry	FWC–FWRI	Compilation of nearshore bathymetry	Statewide	1992–current	http://ocean.floridamarine.org/mrgis/viewer.htm

Chapter 4
Surveillance Networks and Systems

Purpose *To identify current human, animal, and environmental surveillance systems and networks*

The following summary identifies existing human health surveillance networks, including sources of information, reporting requirements, and procedures for identification, confirmation, and follow up on reported cases; included also is a summary of current state surveillance systems to monitor animals and the environment for disease.

Human Surveillance Networks

Background

Adapted from FDOH Bureau of Epidemiology "CHD Guide"Version 1 Final, March 10, 2005

Diseases are a persistent threat to all people, regardless of age, gender, lifestyle, ethnic background, or socioeconomic status. Although some diseases have been controlled by modern medical or technical advances, new disease conditions are constantly emerging. Florida has a large and unique population that continually changes due to the regular influx of visitors, seasonal workers, and new residents. It is the responsibility of the CHD epidemiology programs to be on the front lines of disease prevention and control within this unique population. Although technology will always help by improving methods and tools, the epidemiologist will always be essential for identifying, preventing, and controlling disease in the community.

Each CHD must investigate all cases of"reportable" diseases, including those associated with aquatic toxins from HABs such as NSP. In addition to the reportable diseases, there are new potential health threats from aquatic toxins.These threats are related to the appearance of novel toxins and/or the increased presence of toxin-producing organisms. Current research on aquatic toxin distribution in Florida ecosystems, together with studies on the uptake, distribution, and retention of toxic compounds in laboratory animals, have shown the potential for additional routes of exposure and effects on human health. Describing newly emerging aquatic-toxin-related illnesses will be especially challenging for epidemiologists, environmental health scientists, and other public health researchers due to the lack of information on symptomology, undefined case definitions, the sporadic nature of exposures, and the wide variation in susceptibility. In addition, the effects of chronic exposures are unknown and there is the potential for long term consequences such as immunological suppression and genotoxic outcomes.

SURVEILLANCE

Surveillance is a core public health function and is defined as the regular collection, meaningful analysis, and routine dissemination of relevant data to provide opportunities to prevent and control disease through public health action. Surveillance can be considered"information for action."Surveillance is done for many reasons, such as identifying cases of diseases like meningitis that pose immediate risk to communities; detecting clusters and monitoring trends in disease occurence that may represent outbreaks; evaluating prevention and control measures; and developing hypotheses for the causes of emerging diseases.The basic elements to be addressed when initiating surveillance are system design and purpose, data collection, analysis, information dissemination, and system evaluation.

Surveillance systems fall into two categories—active and passive. Active surveillance consists of searching for cases by calling or visiting hospitals, schools, or other institutions where large numbers of people are closely associated proactively using specific methods to obtain an accurate disease picture. Active surveillance is often conducted within an epidemiological study, with the discovery of a new disease, when an outbreak is detected, or when circumstances prompt public health officials to suspect potential bioterrorism around a high-profile event. Passive surveillance includes traditional reportable disease surveillance, vital statistics, and disease registries. Passive surveillance relies almost entirely upon regular disease reporting by hospitals, physicians, and laboratories to CHDs or the state health office. Electronic reporting systems allow passive reporting to become more rapid and complete.To assure completeness of reporting, an effective surveillance program manager should make periodic visits, at least annually, to all laboratories and infection control practitioners at health care facilities in the county. Such visits permit the CHD to provide facilities with current lists of reportable diseases and develop professional connections. This is especially important when trying to accumulate and disseminate information on emerging illnesses or rare diseases that are not well recognized or understood in traditional health care facilities.

The uncertainty in identifying "cases" of HAB-related illnesses has resulted in the lack of an epidemiological surveillance tool for documenting nonreportable diseases. Efforts to improve this situation by the CDC and a number of participating states including Florida resulted in the design of a HAB-related reporting tool, Harmful Algal Bloom-related Illness Surveillance System (HABISS).

DATA COLLECTION

There are several laws, rules, and regulations that govern the collection of data for the purposes of protecting the public's health. The legal basis for collecting case and laboratory result data for surveillance is found in section 381.0031(1) of the Florida Statutes (F.S.). The list of notifiable diseases is contained in Rule 64D-3.002, Florida Administrative Code. The Florida Administrative Code is a compilation of rules that state agencies use to govern their operations pursuant to the Administrative Procedures Act, Chapter 120, F.S. This allows the FDOH the flexibility to periodically change the list of notifiable diseases without a legislative act, allowing it to conduct surveillance on any unforeseen condition or situation of public health significance that would pose a risk to the population of Florida. Conducting disease surveillance does not end with the list of notifiable conditions.

Communicable disease data collection for surveillance purposes may be accomplished in many ways due to advances in technology such as Web-based surveys and wireless devices. For outbreak purposes, surveillance data are generally collected by questionnaire or by medical chart review and then entered into a database. It is important that a standard data set be collected during any type of surveillance activity to ensure reliable analysis over time and across geographic regions. In Florida, the flow of data collection starts at the community level with reports from the general public, healthcare providers, or clinical laboratories to the CHD. If the data meets the case definition for surveillance, then it moves from the CHD to the state health office and subsequently to the CDC.

Many automated information systems are available in Florida and are used by FDOH for human disease surveillance. Such systems are supported by various animal and environmental surveillance networks managed by other agencies. For effective notification and response, all systems must communicate to identify and address potential public-health threats from HABs.

DISEASE REPORTING

Disease reporting is an example of passive surveillance because it relies on timely data obtained from provider reports and laboratory results. Disease reporting represents only a part of the communicable-disease surveillance picture that also includes any active or passive method for uncovering clusters of disease, monitoring disease burden in the community, and evaluating prevention methods. The importance of timely reporting cannot be overemphasized because late reporting can distort trends, prevent early recognition of outbreaks, and possibly have an effect on prevention measures and program funding. Even with these limitations, reportable-disease surveillance is vital to the health of Floridians because it is a crucial step in controlling and preventing diseases. However, there is always room to improve the quality of reportable-disease surveillance data by improving relationships with community providers.

The legal basis for surveillance of reportable diseases is supported by Florida statute and administrative rule. Section 381.0011, F.S. states, in part:

"Duties and powers of the Department of Health.—It is the duty of the Department of Health to:
"…(7) Provide for a thorough investigation and study of the incidence, causes, modes of propagation and transmission, and means of prevention, control, and cure of diseases, illnesses, and hazards to human health. …"

Section 381.0031, providing specific authority for designating notifiable diseases and for public health agency access to medical records as part of epidemiologic investigations, reads as follows:

"Report of diseases of public health significance to department.—
(1) Any practitioner licensed in this state to practice medicine, osteopathic medicine, chiropractic medicine, naturopathy, or veterinary medicine; any hospital licensed under part I of chapter 395; or any laboratory licensed under chapter 483 that diagnoses or suspects the existence of a disease of public health significance shall immediately report the fact to the Department of Health.
(2) Periodically the department shall issue a list of infectious or noninfectious diseases determined by it to be a threat to public health and therefore of significance to public health and shall furnish a copy of the list to the practitioners listed in subsection (1).
(3) Reports required by this section must be in accordance with methods specified by rule of the department.
(4) Information submitted in reports required by this section is confidential, exempt from the provisions of s. 119.07(1), and is to be made public only when necessary to public health. A report so submitted is not a violation of the confidential relationship between practitioner and patient.
(5) The department may obtain and inspect copies of medical records, records of laboratory tests, and other medical-related information for reported cases of diseases

of public health significance described in subsection (2). The department shall examine the records of a person who has a disease of public health significance only for purposes of preventing and eliminating outbreaks of disease and making epidemiological investigations of reported cases of diseases of public health significance, notwithstanding any other law to the contrary. Health care practitioners, licensed health care facilities, and laboratories shall allow the department to inspect and obtain copies of such medical records and medical-related information, notwithstanding any other law to the contrary. Release of medical records and medical-related information to the department by a health care practitioner, licensed health care facility, or laboratory, or by an authorized employee or agent thereof, does not constitute a violation of the confidentiality of patient records. A health care practitioner, health care facility, or laboratory, or any employee or agent thereof, may not be held liable in any manner for damages and is not subject to criminal penalties for providing patient records to the department as authorized by this section.

(6) The department may adopt rules related to reporting diseases of significance to public health, which must specify the information to be included in the report, who is required to report, the method and time period for reporting, requirements for enforcement, and required follow-up activities by the department which are necessary to protect public health."

The Privacy Rule of the Health Insurance Portability and Accountability Act (HIPAA) protects personal health information, but does not restrict the ability of county and state health departments to obtain such information when its collection is authorized by state law. A full discussion of the public health dimensions of HIPAA is available in the Morbidity and Mortality Weekly Report (MMWR) at http://www.cdc.gov/mmwr/preview/mmwrhtml/su5201a1.htm).

Reportable diseases caused by aquatic toxins include SPFP, CFP, NSP, and PSP. The FDOH Bureau of Epidemiology and the Division of Environmental Health rely on CHDs, healthcare providers, laboratories, PCCs, and other public health personnel to report the occurrence of these poisonings.

Surveillance Systems Used by FDOH

Florida Department of Health Emergency Notification System

www.fdens.com

CDC guidelines define the intended purpose of a Health Alert Network (HAN) as an information system to identify public health emergency events 24 hours a day, every day of the year, provide relevant and timely information, and alert both public health professionals and those public health partners who are key to a successful response. The Florida Department of Health Emergency Notification System (FDENS) is Florida's HAN.

In 2004, the FDOH recognized that national, statewide, and multicounty events had drawn attention to the need for large public service organizations to more effectively coordinate efforts across geographic and regional boundaries when responding to a disaster or a public health emergency. Several specific needs were identified, all of which were designed to provide centralized and uniform practices within the FDOH itself, as well as in their public health partners. The first need was to create a centralized and uniform method to collect and organize contact information from all parties. Next, there had to be a consistent and centralized method for issuing emergency alerts and information, including confirmation from the recipient entity. Finally, there was a need for all parties to have updated and uniform communication devices, such as land-line, cellular, and satellite phones; fax capability; and more sophisticated e-mail and internet connections.

The creation of FDENS was not intended to replace existing localized procedures for collecting contact information nor was it intended to replace well-established emergency procedures already in place. By augmenting the current procedures of all participants and providing an umbrella of support, FDENS ensures an ongoing, consistent flow of information while providing for backup and redundancy.

BENEFITS AND CAPABILITIES OF FDENS

- Web access
- A centralized user registry
- A multi-device alerting function
- A password-protected Web site
- Required confirmation of receipt of the alert notification
- Confirmation tracking to ensure that the appropriate people have been notified
- Reduction in duplicate messaging
- Establishment of a collaborative work environment so that sensitive disaster-planning and response information may be securely shared between local and state health agencies
- Licensing and permission levels for access to specific information
- Integration of the EpiCom system into FDENS

An FDENS tutorial is available online at http://www.flhan.com/ or https://epicomfl.com/Attachments/FDENS_Tutorial.htm

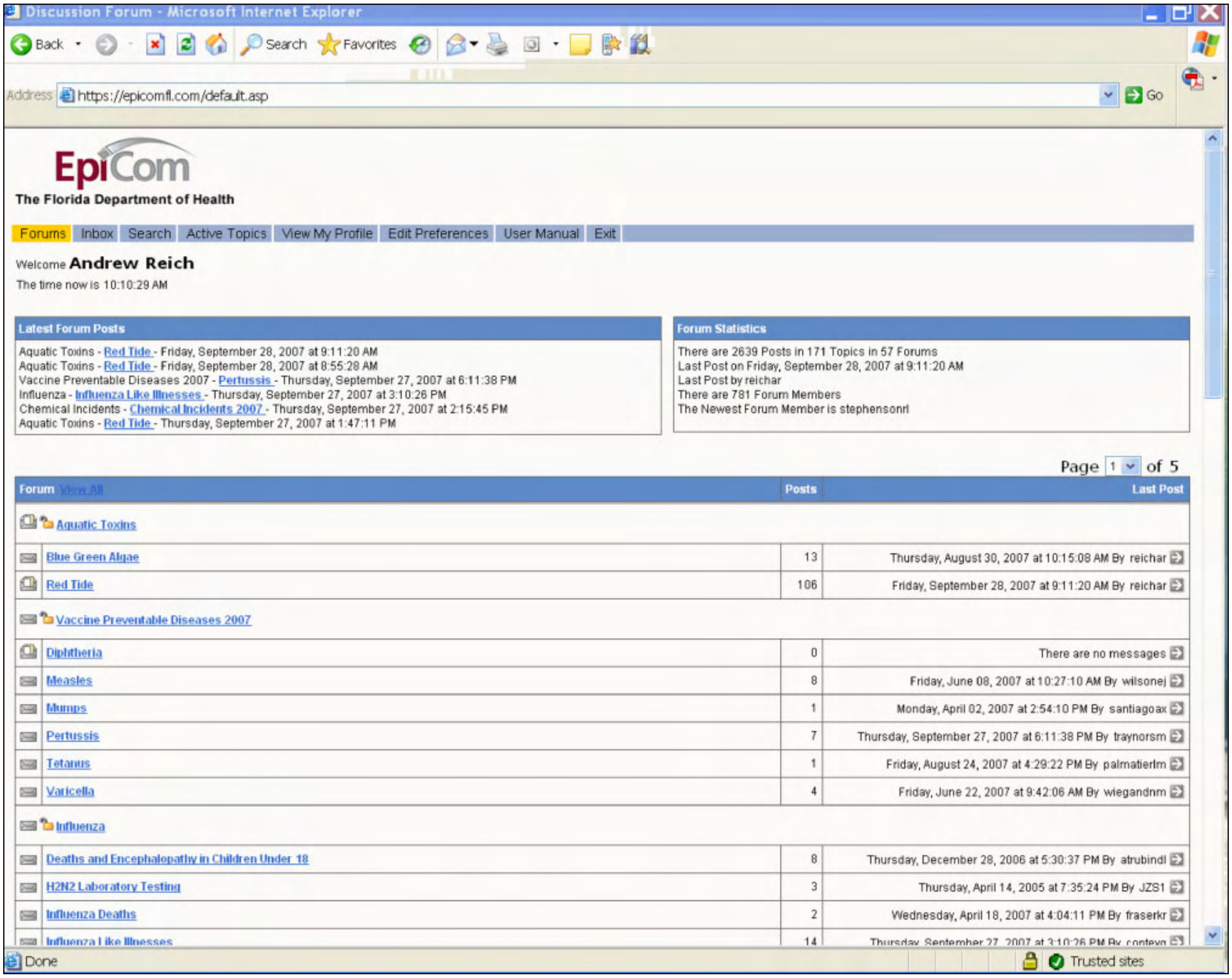


Figure 4.1 *EpiCom Web site forums screen.*

EpiCom

Adapted from FDENS/EpiCom Web site

EpiCom is the Web-based surveillance portion of FDENS developed and maintained by the FDOH, Division of Disease Control, Bureau of Epidemiology. EpiCom allows for immediate real-time exchange of information for health care practitioners and other partners on disease outbreaks or other incidents, such as red tide blooms, flu vaccination shortages, or hurricane response. EpiCom users include healthcare practitioners throughout Florida, such as physicians, CHD staff, and other Florida state agencies. All FDENS users have access to EpiCom and can submit information on a specific topic. All information submitted by FDENS users is reviewed by a moderator who is approved and trained by the FDOH. A moderator's function is to review the information posted to EpiCom to ensure it is added to the correct topic and does not contain personally identifiable information. The EpiCom system is composed of three main components: EpiCom Exchange, EpiCom Alert, and ER Surveillance.

EpiCom Exchange is a secure, Web-based anecdotal public health surveillance system designed to solicit public health information from a variety of sources and to share that information with other users across the state. Confirmed or potential cases are reported through "postings" and approved and categorized by Bureau of Epidemiology staff and moderators in the Division of Environmental Health. Messages are sent through the EpiCom system via e-mail to affected groups, making the FDOH responsible for recognizing public health threats in the shortest time possible. Once a threat is identified, EpiCom Alert is employed to issue emergency notification to selected EpiCom users. Users are alerted via registration information that

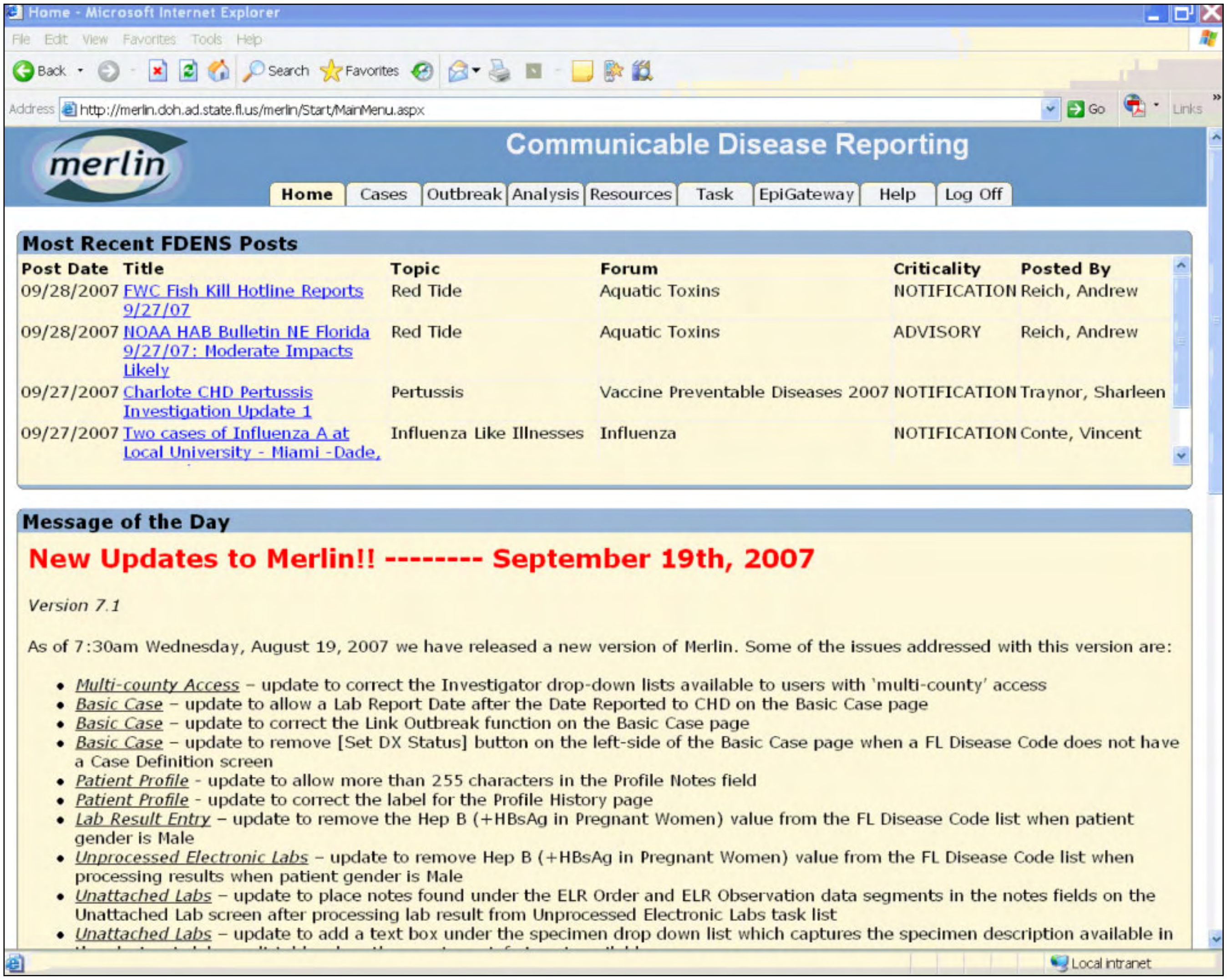


Figure 4.2 *Merlin® Web site home page.*

includes office, home, and cellular telephone numbers as well as e-mail addresses. The ER Surveillance tool is used by hospitals to enter daily emergency room registration counts. Once data is entered, ER Surveillance can provide graphs to track census trends, including anomalous variations.

EpiCom has a number of "forums" that are currently being used for HAB-related surveillance and for timely dissemination of information. These include ongoing reports of shellfish poisonings and related issues, such as ciguatera and STX-associated investigations in the Waterborne Illness Program Food and Waterborne Disease forum. A newly created Aquatic Toxins forum contains postings of environmental conditions such as red tide blooms that have high potential for affecting gulf coastal communities, NOAA Bulletins with anticipated bloom movements derived from satellite imagery, FWC–FWRI status updates, and reports of cyanobacterial blooms and conditions in major freshwater bodies in Florida. The forums represent an excellent tool and an opportunity for gaining insights and generating peer-reviewed discussions on aquatic toxin-related subjects.

An EpiCom tutorial is available online at http://www.flhan.com/ or https://epicomfl.com/Attachments/FDENS_Tutorial.htm

Once logged on, there is a screen showing the numerous forums available to registered users (Figure 4.1).

Merlin®: Florida Reportable Disease System

Adapted from the Merlin® User Manual

Merlin® is the FDOH Bureau of Epidemiology's Web-based system for reporting, managing, and performing epidemiological analysis of communicable-disease information. It is the primary reporting tool for all CHDs and is also utilized by all the various bureaus and divisions within the FDOH. The Web-based application runs from a central FDOH intranet server in Tallahassee and is accessed through Microsoft® Internet Explorer®. Merlin® is a thin client application, which eliminates the need to load any software or updates onto the user's terminal.

All disease conditions have separate clinical and surveillance case definitions; a given case may not always be reportable. A case of hepatitis A may meet the clinical case definition but not have a confirming lab result. Clinically, this is a case of hepatitis, but it would not be reportable because it does not meet the case definition for surveillance. Merlin® enables counties to report cases to the FDOH in real time; the FDOH Bureau of Epidemiology then reports to the CDC in Atlanta on a weekly basis. Information on the required reportable diseases involving aquatic toxins (NSP, CFP, SPFP, and PSP) can be found in Appendix B, Medical Fact Sheets and Case Definitions.

The Merlin® morbidity database is a dynamic database. Counties report and update many cases every week. The CDC accepts all new cases and updates during the course of a morbidity year and publishes all morbidity counts, by reporting week, in the Morbidity and Mortality Weekly Report (see www.cdc.gov/mmwr).

BENEFITS AND CAPABILITIES OF MERLIN®

- Ability to electronically review and analyze county and statewide disease trends
- Ability to export disease information for more sophisticated analysis
- Quick and easy data entry
- Availability of printable reports and documents
- Receipt and processing of electronic laboratory data
- Potential for more timely reporting
- Detection of potential disease outbreaks and clusters
- Availability of a Helpdesk for submitting questions and requesting assistance
- Ability to manage, investigate and analyze information from a variety of outbreak/cluster types, including: reportable and nonreportable diseases, symptoms/syndromes and other events of public health importance

The Merlin® Training site can be accessed at http://merlintraining.isf.com/MerlinNet/start/Login.aspx (Figure 4.2).

Florida Poison Information Center

The three Florida Poison Information Centers (FPIC) were created in 1989 by an act of the Florida Legisla-

FPIC image

Florida Poison Information Center, Miami

ture (F.S. 395.038). The centers provide an invaluable service to the citizen community, health care professionals, visitors, and the FDOH. Calls to the FPICs are handled by specially trained nurses, pharmacists, physician assistants, physicians, and on-call board-certified toxicologists who have computerized access to the latest in-depth health and safety assessment tools. The FPICs are located in Miami, Tampa, and Jacksonville and serve all Florida counties and beyond, operating toll-free and in all major languages 24 hours a day, 7 days a week, 365 days a year. The FPIC/Miami, located at the University of Miami Miller School of Medicine and Jackson Health Systems, in particular has rapidly grown into a cost-effective model for poison center systems.

In 1997, with funding from the FDOH, the CDC, and the National Institute of Environmental Health Sciences (NIEHS) Marine and Freshwater Biomedical Sciences Center, the FPIC/Miami established an additional free hotline dedicated to providing information concerning aquatic health issues (1-888-232-8635). The "Aquatic Toxins Hotline" allows users to access information using an automated call-processing menu system. Callers can listen to prerecorded information about possible health effects and locations of red tide blooms (including the NOAA HAB Bulletin [coastwatch.noaa.gov/hab/bulletins_ ns.htm], updated twice weekly). They can also obtain information about marine toxin issues in general, and have the opportunity to speak to a Specialist in Poison Information (SPI). The hotline also provides callers with accurate, timely, and understandable information on other aquatic toxins including ciguatoxin, STX, and those associated with cyanobacteria.

The Aquatic Toxins Hotline has been expanded to

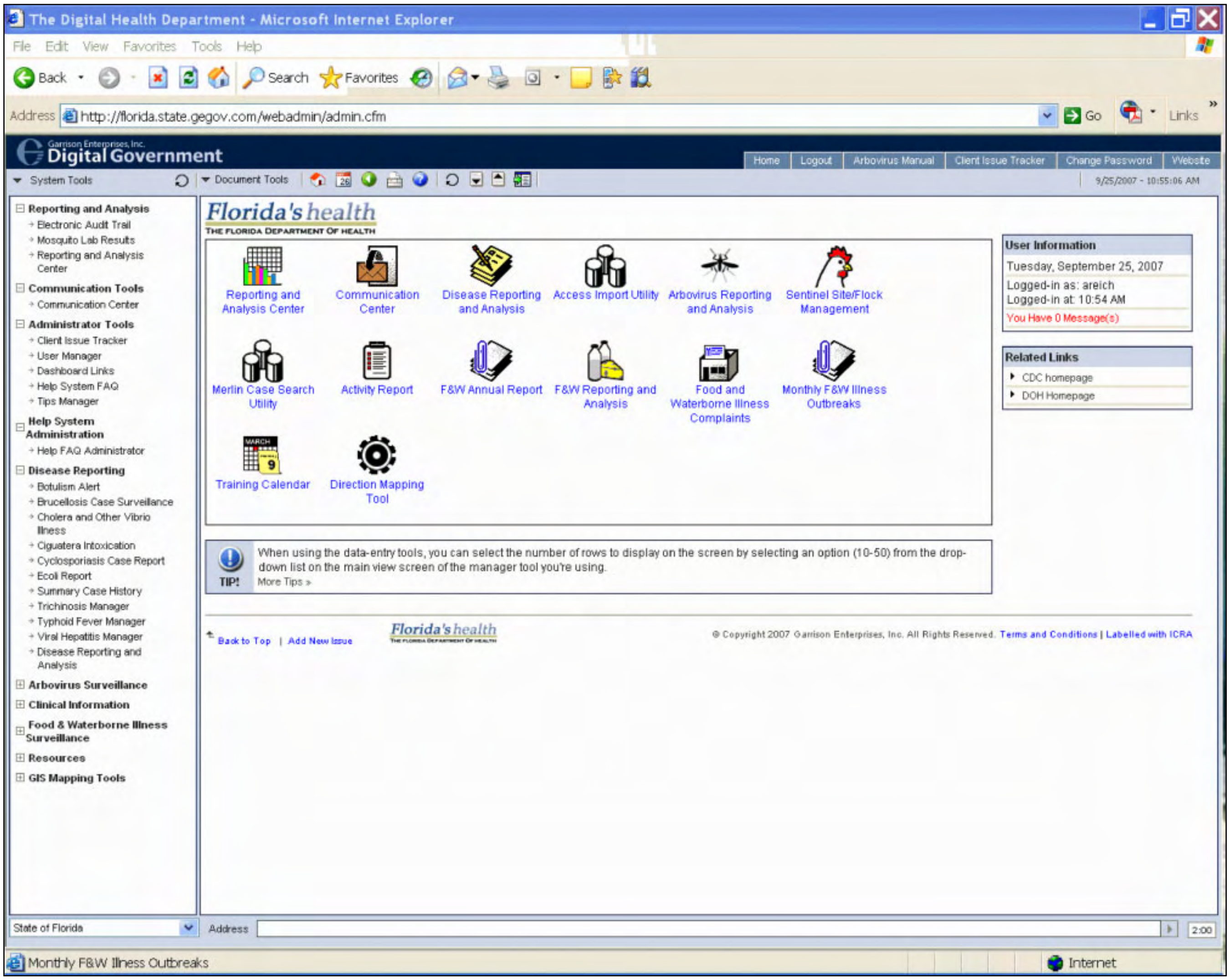


Figure 4.3 *Food, Water and Vector-borne Surveillance System (FWVSS) Web site home page.*

all FPICs and currently provides the only way for the public to receive the NOAA HAB Bulletin in a convenient audio format. Callers are also provided with a Web site that displays the NOAA HAB Bulletin and information in the form of a detailed map, as well as the Web site for FWC–FWRI with further information about red tide, its causative organism, and ongoing research in the field. The FWC–FWRI also generates biweekly reports of current statewide red tide status, available on its Web site as well as in audio format.

Food, Water and Vector-borne Surveillance System

The Web-based Food, Water and Vector-borne Surveillance System (FWVSS) (Figure 4.3) was created to manage data generated by the Food and Waterborne Disease Program and the Arbovirus Surveillance Program and enhances the ability to monitor for—and respond quickly to—food-, water-, and vector-related disease outbreaks. The Food and Waterborne Disease Program data include summary data, including geographic elements, on food and waterborne disease outbreaks from 1994 to the present, as well as food- and water-related complaints. Data includes HAB-related illnesses such as NSP, SPFP, and CFP. (Single case data for reportable diseases [notifiable per Florida Statutes Chapter 64D-3, F.A.C.] are entered in and maintained by the Merlin® surveillance system.) FWVSS is searchable by multiple fields, including county of outbreak, outbreak type, investigation and summary dates, vehicles of transmission, implicated pathogen, and contributing factors (contamination, proliferation, survival, method of cooking). The FWVSS generates user-specified reports automatically or by user-determined fields.

Syndromic Surveillance Systems

The CDC applies the term "syndromic surveillance" to surveillance using health-related data that precede actual diagnosis and signal the probability of a case or an outbreak of sufficient seriousness to warrant a further public health response. Historically syndromic surveillance has been used to target the investigation of potential cases; its utility for detecting outbreaks associated with HABs is being explored by the FDOH ATP.

Electronic Surveillance System for the Early Notification of Community-Based Epidemics

Electronic Surveillance System for the Early Notification of Community-Based Epidemics (ESSENCE) is a Web-based syndromic surveillance system available 24 hours a day, 7 days a week. It was originally developed by the Department of Defense and Johns Hopkins University for Military Treatment Facilities in the National Capital Region but is currently available in 37 hospitals in five Florida counties: Volusia (2), Palm Beach (4), Monroe (2), Miami-Dade (14), and Broward (15). The ESSENCE system performs automated electronic data collection and analysis of health information using algorithms for temporal and spatial detection based on Emergency Department chief complaints. ESSENCE uses the information gathered to make statistical models for syndromic surveillance and alert detection. This includes making predictions based on previous several weeks of data, detecting irregularities in public health surveillance data, and identifying geographic clusters (Kite-Powell, 2007).

Data collected from emergency rooms and analyzed using various methods includes the following: date and time of visit, the hospital name and region, patient county of residence, age, sex, chief complaint, discharge diagnosis, and admission status. Data collection options in ESSENCE include different record formats and collection frequency.

Syndrome categories used for surveillance include 102 established categories that include the following: botulism-like illness, neurological, hemorrhagic illness, rash, gastrointestinal illness, and respiratory illness. Other categories established using the chief complaint query mechanism include the following: dialysis, animal bite, rabies, diarrhea or vomiting, and asthma. Syndrome definitions are used be sure the illness is properly categorized.

Generally, ESSENCE monitors syndromic surveillance using the following steps:

- Each morning hospitals transmit Emergency Department chief complaint data
- System monitoring and review process
  - Evaluation of the alert list and time series data by
    - Date of visit, time of visit, age, gender, zip code, hospital
    - Clustering of chief complaints
- If further investigation is warranted, data reviewed by the medical epidemiologist
- If necessary, hospital infection control practitioner (ICP) is contacted for chart review

BENEFITS AND CAPABILITIES OF ESSENCE

- Geographic Information Systems component for spatial cluster detection
- Syndrome definitions
- Subsyndrome categories
- Updated detection algorithms
- Expandability to other data sources
- Designed to capture naturally occurring infectious disease and bioterrorism data

HABISS: CDC's Multi-State HAB Surveillance System

In response to the need to support public health decision-making, the CDC National Center for Environmental Health in Atlanta has developed HABISS. The HABISS is a unique surveillance system that includes both human and animal health data as well as environmental data about HABs themselves. Data collection is organized in a modular format that can be expanded to suit the needs of state and local health and environmental protection agencies. In the future, data collected and stored in HABISS will be used to assist in predicting local HABs, thus allowing state public health and environmental health prevention activities to be in place, not only in response to reports of human or animal illnesses, but also in advance of anticipated public health problems.

HABISS is a surveillance system that can be accessed online through the Web and offline through Windows®-based or hand-held devices. It operates on top of a secure platform, the Rapid Data Collector (RDC). The RDC tool was designed in-house, specifically for survey-design and data-collection purposes. Protected by approved access and password, state-based users can choose to enter, edit, and save data for subsequent sessions. Users may also choose to export data to Access, Excel, or XML. The HABISS requires users to input several key indicators (*e.g.*, dates, agency contact information, state codes, route of exposure, patient's chief complaint). If data are available, HABISS also prompts users to include the following elements for a suspected human illness report:

- Point of contact with the system

- Identifying information for the case
- Case demographics
- Environmental information
- Exposure information
- Signs and symptoms
- Medical review (including laboratory analysis)
- Case assessment and follow-up
- Parallel modules for animal events

Users are requested to report the following data elements on algal blooms:

- Water-sample and collection information
- Geographic coordinates via Google™ Maps
- Toxin identification

Human illness reports can be easily linked to data collected on algal blooms. It is intended to synthesize information not only on regional algal blooms across multiple sites, but also on active blooms in residential ponds, reservoirs, natural springs, and other water bodies.

Surveillance Systems Maintained by Other Agencies

HABs negatively affect environmental and animal health in addition to potentially threatening human health. Surveillance systems designed for health monitoring, response, and reporting in any of these areas can serve as indicators for HAB-related illness threats.

FWC–FWRI: Red Tide Status Report

http://research.myfwc.com/features/view_article.asp?id=9670
1-866-300-9399 inside Florida, 727-552-2448 outside Florida

The FWC–FWRI produces biweekly reports of current statewide red tide status. Reports include map of sampling results and regional status reports. Reports are generated by the FWC–FWRI's coordinated year-round statewide comprehensive red tide monitoring program. Scientists investigate and monitor red tide and other HABs in coastal and estuarine waters around the state.

FWC–FWRI: Volunteer Monitoring Program

http://myfwri.com/features/view_article.asp?id=24851
or contact the FWC–FWRI HAB Group 727-896-8626

Volunteer nearshore and offshore sampling of estuarine and marine waters is coordinated by FWC–FWRI to assist with monitoring HABs in Florida, increase coverage of the Gulf of Mexico, create early warning of offshore blooms, and develop partnerships with the marine business and research community. Volunteers consisting of FWC scientists, other state agencies, stakeholder groups, charter and fishing captains, retirees, divers, and researchers as well as private institutes collect up to 200 water samples with greater than 70 HAB species weekly. The FWC scientists perform sample analysis for HAB species, note data in the HAB Historical Database, and ensure that appropriate actions and reporting, such as shellfish bed closures by FDACS and weekly HAB bulletins from FWC–FWRI and NOAA, follow detection.

USF–FWC Center for Prediction of Red Tides

http://ocgmod1.marine.usf.edu/pyocean-Web/

The Center for Prediction of Red Tides is a collaborative effort between the USF College of Marine Science and FWC to develop USF red tide research monitoring tools. Satellite imagery, physical oceanography monitoring buoys, physical ocean models, and red tide predictive models are all tools being evaluated for use in FWC statewide red tide monitoring efforts. The Center for Prediction of Red Tides Web site includes an experimental forecasting product which predicts daily bloom movements based on current FWC red tide cell counts and USF current speed and direction data.

NOAA HAB Bulletin and Forecasting System

http://coastwatch.noaa.gov/hab/bulletins_ns.htm
or contact hab@noaa.gov

The HAB bulletin generated by NOAA and the National Environmental Satellite Data and Information Service for the Gulf of Mexico provides notification of bloom conditions to state and local coastal managers. Bulletins include information on wind conditions, chlorophyll levels, and potential or actual bloom events and are sent twice a week via e-mail to registered users with natural-resource management responsibilities to alert subscribers of developing blooms and changes in the location and extent of existing blooms. Bulletins can be accessed online 48 hours following e-mail distribution.

Reports are generated from a variety of information sources including the NOAA HAB Forecasting System (*http://www.csc.noaa.gov/crs/habf/*), which supplies information on the location, extent, and potential for development or movement of HABs in the Gulf of Mexico, and for advance warning of potential events (posted twice weekly during HAB season). The forecasting system relies on satellite imagery, field observations, and buoy data to provide the large spatial scale and high frequency of observations required to assess bloom location and movements.

FDACS Division of Aquaculture: Shellfish Harvesting Management

http://www.floridaaquaculture.com/SEAS/SEAS_mngmt.htm

FDACS regulates aquaculture facilities, shellfish processing plants, and shellfish-harvesting areas to protect human health. Current open/closed status and maps of shellfish area classifications can be obtained 24 hours a day from the Shellfish Environmental Assessment Section (SEAS) Web site or by contacting one of the following FDACS field offices:

- Headquarters, Tallahassee 850-488-5471
- Western Gulf, Panama City 850-236-2200
- Central Gulf, Apalachicola 850-653-8317
- Big Bend Gulf, Cedar Key 352-543-5181
- South Gulf, Punta Gorda 941-255-2552
- Atlantic, Palm Bay 407-984-4890

Violations, unlawful possession, or harvesting of cultured shellfish from closed areas can be reported to 1-800-DIAL-869. FDACS offices provide information on areas closed for shellfish harvesting due to threats that the shellfish are unsafe for consumption. Closures may be based on harmful levels of enteroccoci or fecal coliform bacteria or on emergency conditions such as red tide blooms, hurricanes, or tropical storms. Shellfish areas are reopened for harvest when sampling demonstrates that stringent water-quality criteria are met to ensure that shellfish are wholesome. Shellfish bed closures caused by red tide are based on *K. brevis* cell counts of 5,000 cells per liter of seawater or greater and confirmation of brevetoxin toxicity by MBA.

MML: Beach Conditions Reporting Program

http://coolgate.mote.org/beachconditions/
1-941-BEACHES

The MML Beach Conditions Report provides several types of information about beach conditions during red tide events: presence of dead fish, respiratory irritation among beachgoers, water color, and wind direction. Reports are provided by county lifeguards and updated at 10 a.m. and 3 p.m. daily. Information gathered also contributes to the NOAA HAB Bulletin.

FWC: The Florida Fish-Kill Hotline

http://research.myfwc.com/fishkill/submit.asp
1-800-636-0511

The Fish-Kill Hotline is a tool by which researchers monitor fish disease and mortalities throughout the state. The hotline provides a means for governmental agencies and the public to directly report fish kills, diseased fish, or fish with other abnormalities. The FWC–FWRI's Fish and Wildlife Health Group may then respond with an investigation of the kill either directly or through its network of more than 350 contacts. Although the hotline is primarily a resource regarding marine fish kills, calls are regularly received about mortalities of freshwater fish, and of birds and other wildlife, which are then referred to the appropriate department, agency, or organization. Historical records regarding fish kills and disease events may also be accessed by the public at http://research.MyFWC.com/fishkill/.

FWC: Wildlife Alert Hotline

*1-888-404-FWCC (3922), cell phone users *FWC or #FWC*

The FWC's Wildlife Alert Hotline is a 24-hour public hotline for reporting animal injury or death or suspected wildlife law violation. The hotline aids in the monitoring of sick, dead, injured, or tagged manatees; dead or injured marine turtles; right whale sightings; illegal hunting, killing, or capturing of protected species; fishing by illegal methods; and boating under the influence.

FWC: Wild Bird Die-Offs

http://myfwc.com/bird/

The FWC provides an online reporting system for surveillance of wild bird die-offs that aids in the monitoring of Avian Influenza, West Nile Virus, and bird electrocutions from power lines.

FDACS: Division of Animal Industry

The FDACS Bureau of Animal Disease Control and Bureau of Diagnostic Laboratories enforce animal health regulations to protect Florida from animal pests and diseases that have a major economic and public health consequence. Mandatory reporting of specific infectious and communicable diseases exists to eradicate them from livestock and other domestic animals. Information on HAB-related illnesses is lacking and they are not reportable, but the Kissimmee Animal Diagnostic Lab (KADL) is working with FWC to develop response and analytical capabilities for addressing potential livestock kills that are due to exposure to cyanobacteria in freshwater ponds, lakes, and reservoirs.

If any unusual animal disease or pest that might indicate a possible newly emerging disease with the potential to cause human disease, economic damage, or an animal mortality event in unusually high numbers is discovered in the state, a report should immediately be made to the State Veterinarian: office hours, 850-410-0900; fax, 850-410-0915; after hours, 1-800-342-5869; e-mail, rad@doacs.state.fl.us).

Chapter 5
Regulatory Guidelines

Purpose *To identify existing and developing regulatory guidelines and public health policies intended to protect human health from exposures to harmful algae and their toxins.*

This section provides an overview of public health policies concerning the effect of harmful algae and their toxins on human health. Included are existing policies, the historical background on their development, and what future regulations may be needed. It includes sections regarding shellfish, fish, and both drinking and recreational waters, with supplemental regulatory guidelines concerning blue-green algae. This is not a comprehensive review of all policies affecting Florida; there are additional local, state, and federal laws that may apply to related activities.

Shellfish

Historically, algal biotoxin-related public health policies targeted illnesses resulting from the consumption of contaminated molluscan shellfish. Public health controls of shellfish became a national concern in the U.S. in the late nineteenth and early twentieth centuries when public health authorities noted a large number of illnesses associated with consuming raw oysters, clams, and mussels. In 1925, the Surgeon General of the U.S. Public Health Service convened a conference on shellfish sanitation in response to requests from local and state public health officials for assistance.

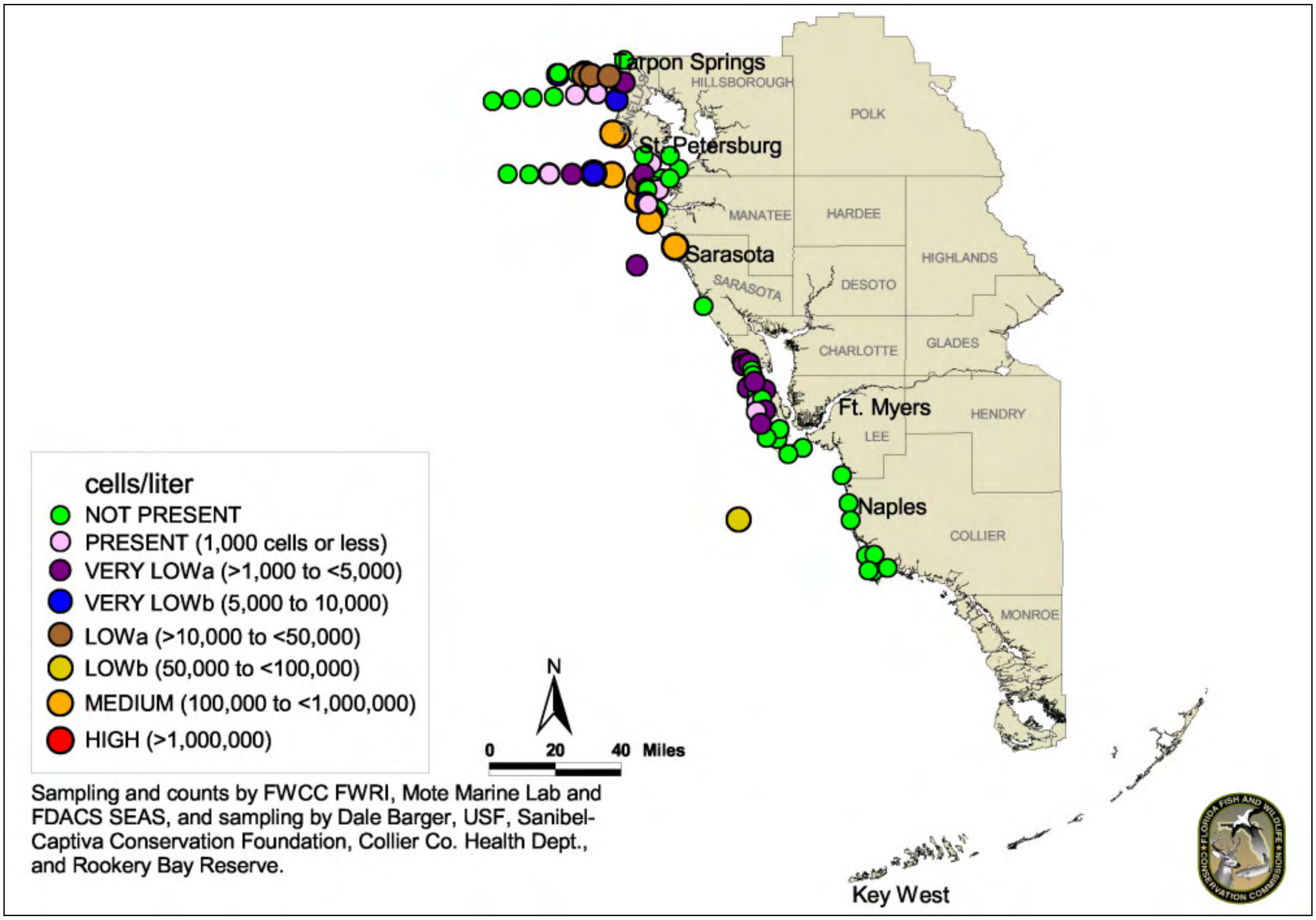
The National Shellfish Sanitation Program (NSSP) was first developed based on the public health principles and controls formulated at the 1925 conference. The public health control procedures later established by the NSSP Manual of Operations were dependent on the cooperative and voluntary efforts of state regulatory agencies and the voluntary participation of the shellfish industry. In 1975, the FDA decided that NSSP goals would best be met by making periodic revisions to the Manual of Operations rather than by implementing mandatory NSSP regulations. To establish standard national guidelines for shellfish, state regulatory officials along with the National Marine Fisheries Service (NMFS), the Environmental Protection Agency (EPA), and the shellfish industry organized the Interstate Shellfish Sanitation Conference (ISSC) in 1982. In 1984, the ISSC entered into a formal Memorandum of Understanding with the FDA to promote shellfish sanitation through the NSSP. Under this agreement, ISSC members are required to adopt laws and regulations to ensure that shellfish are grown, harvested, and processed in a safe and sanitary manner. The FDA is responsible for the annual review of each states' shellfish-control program to assure conformity with the NSSP standards and guidelines. The FDA also established action levels for four of the five recognized shellfish poisoning syndromes in the U.S.:

PSP: 0.8 ppm (80 µg/100 g) saxitoxin equivalent;
NSP: 0.8 ppm (20 MU/100 g) brevetoxin-2 equivalent;
DSP: 0.2 ppm okadaic acid plus 35-methyl okadaic acid (dinophysistoxin-1); and
ASP: 20 ppm domoic acid, except in the viscera of Dungeness crab, where 30 ppm is permitted.

As a member of the ISSC, Florida formalized a federally approved marine biotoxin contingency plan. Under the state's Comprehensive Shellfish Control Code, Chapter 5L-1, F.A.C., FDACS is responsible for classification and management of shellfish-harvesting areas to ensure that shellfish are grown, harvested, and processed in a safe and sanitary manner. Harvesting areas are classified as Approved, Conditionally Approved, Restricted, Conditionally Restricted, Prohibited, and Unclassified. Waters that are not classified are considered to be unapproved for all molluscan shellfish harvesting (Heil, 2009).

The FDACS also oversees the operation and maintenance of 1,200 bacteriological sampling stations to routinely monitor fecal coliform and water-quality parameters in each of Florida's shellfish-harvesting areas. Harvesting areas can be temporarily closed in response to pollution events, such as sewage spills, hurricanes, or toxic algal blooms. If a harvesting area is closed in response to an event, sample results must meet the appropriate NSSP standard and adequate time must elapse for shellfish to purify themselves before the area can be reopened. Classification and open and/or closed status of shellfish harvesting areas, along with violation penalties, apply to both commercial and recreational shellfish harvest. It is a criminal violation to harvest any species of oysters, clams, or mussels from any area that is not classified as "open" or during "closed" status.

To address the threat of NSP, guidelines are in place under Chapter 5L-1.003(8), F.A.C. for monitoring and closing shellfish areas when *K. brevis* cell concen-



FWC image

Figure 5.1 *Example of an FWC–FWRI red tide status report map,* Karenia brevis *counts.*

trations reach dangerous levels. Background levels of *K. brevis* in Florida are usually 1,000 cells or fewer per liter of seawater. When cell concentrations exceed 5,000 cells per liter, affected shellfish-harvesting areas are temporarily closed. Harvesting areas are reopened when *K. brevis* cell counts fall below 5,000 cells per liter and MBA tests verify that bivalves are safe to consume (<20 MU/100 g shellfish tissue) (Heil, 2009) (Figure 5.1).

In 2003, following the 2002 outbreaks of SPFP in the IRL, FDACS collaborated with FWC and was initially assisted by the FDA to implement an STX contingency shellfish monitoring program to protect the public from PSP, similar to the FDACS program for NSP monitoring. FDACS collects monthly samples of water and hard clams, *Mercenaria* sp., from three representative shellfish harvesting areas in the IRL. FWC–FWRI analyzes water and shellfish for *P. bahamense* and STXs, respectively. Following NSSP guidelines and FDA action levels, FDACS closes shellfish-harvesting areas when STX levels in shellfish exceed 80 µg STX eq./100 g tissue (edible portion) and reopens them only when STX concentrations fall below the action level.

Fish

Saxitoxin Puffer Fish Poisoning

In 2002, Florida health officials were notified of numerous cases of severe neurological illnesses associated with the consumption of puffer fish harvested from the Titusville area of Florida (Bodager *et al.*, 2002; Hammond *et al.*, 2002; Marcus *et al.*, 2002). Symptoms were consistent with PSP, which in the U.S. has generally been associated with the consumption of molluscan shellfish from the northeastern and northwestern coastal regions of the country. Subsequent laboratory tests of puffer fillet samples confirmed that STX was the causative agent in the reported illnesses (Quilliam *et al.*, 2004; Landsberg *et al.*, 2006).

In response to the puffer fish poisoning cases, the FWC issued an executive order in April 2002 placing a 90-day ban on puffer fish harvest from Volusia, Brevard, Indian River, and St. Lucie county waters. Species of puffer fish covered by the harvest prohibition included southern (*Sphoeroides nephelus*), northern (*S.*

maculatus), marbled (*S. dorsalis*), bandtail (*S. spengleri*), checkered (*S. testudineus*), and least (*S. parvus*) puffer fish. A second executive order was issued in July 2002, which extended the ban an additional 90 days and added Martin County to the list of affected areas. Because tests showed that puffer fish in these areas continued to be toxic, FWC issued two consecutive one-year bans, effective through October 22, 2004. FWC finally concluded that because STX levels in puffer fish were remaining far above the FDA action limits, a long-term ban on their harvest was necessary. Therefore, Chapter 68B-3.007, F.A.C., which extended indefinitely the puffer fish harvesting ban in these areas, was passed in July 2004.

Ciguatera Fish Poisoning

In many parts of the world, tropical reef fish are known to be highly likely vectors for ciguatera. Local knowledge of this fact in both the Caribbean and other tropical island communities has influenced fishing behavior and eating customs. However, there are only limited examples of regulatory restrictions on harvesting. These have been reported to include American Samoa; Queensland, Australia; French Polynesia; Fiji; Hawaii, and Miami (De Fouw *et al.*, 2001). The report of a prohibition on the harvesting of barracuda in Miami, Dade County, though referenced (Lawrence *et al.*, 1980), has not been confirmed.

Drinking Water

The need for regulatory approaches to reduce human exposures to cyanotoxins was underscored at the 6th International Conference on Toxic Cyanobacteria, held in Bergen, Norway, in June 2004. Many of the 190 participants, representing 36 countries, reported data suggesting a high frequency of cyanotoxin occurrence in drinking water in concentrations that may be hazardous to human health.

Worldwide, the leading route of human exposure to cyanobacteria is through the consumption of drinking water (Gupta, 1998). Urban drinking-water systems have been implicated in most suspected cases of cyanobacterial poisoning in communities in which the reservoir had a recorded cyanobacteria bloom and, in several instances, had been treated with copper sulfate (Carmichael and Falconer, 1993; Falconer, 1996).

Guidelines for the total daily intake over a lifetime of a chemical compound in drinking water is typically calculated by applying the derived tolerable daily intake (TDI) to typical daily consumption in liters by an individual of a given body weight (bw) while taking into consideration the proportion (P) of the total daily intake of the compound that is ingested through drinking water and the average daily drinking-water consumption in liters (L). The resulting formula is as follows:

$$\text{Guideline value} = \frac{\text{TDI} \times \text{bw} \times \text{P}}{\text{L}}$$

In their addendum to the second edition of *Guidelines for Drinking-Water Quality* (1998b), the WHO published a provisional health-based drinking-water guideline value of 1.0 µg/L for the total daily intake of microcystin-LR (MC-LR) (free plus cell-bound) for an average adult assuming TDI = 0.04 µg/kg, bw = 60 kg, P = 0.8, and L = 2. The WHO based the guidelines on studies reporting a lowest observable adverse effect level (LOAEL) on the toxicity of MC-LR in mice or rats exposed to contaminated drinking water (Fawell *et al.*, 1994; Heinze, 1999). Discrepancies in the data derived from the studies suggest a potential for substantial differences in LOAEL between different strains of rats and/or mice. An intermediate exposure value cannot be determined because the current data available on the toxicity of MC-LR is not adequate. Available data does not show whether intermediate exposure to drinking water containing 10 µg/L of MC-LR or less would result in adverse effects on human health (Burch, 2008). A health advisory level (HAL) presented as 10 µg/L/day is based on many assumptions because the database for the toxicity of microcystins is very limited and alternative HAL values could be justifiably proposed. The WHO concluded that insufficient data were available upon which to derive guideline values for any other cyanobacterial toxins, including anatoxins, STXs, and cylindrospermopsin.

After the release of the WHO provisional drinking water guidelines, many countries adopted the value directly or derived slight variations. Despite limited data, some countries also developed guidance values for other cyanotoxins, such as cylindrospermopsins, anatoxins, and STXs (see Table 5.1). Currently, Florida does not recognize any regulatory guidelines.

In the U.S., the Safe Drinking Water Act (SDWA) authorizes the EPA to set national health-based standards to protect against both naturally occurring and man-made contaminants that may be found in drinking water. Although the EPA has developed and implemented regulations for more than 90 drinking water contaminants, it has yet to create regulations or guidelines addressing cyanobacteria in drinking-water supplies. Awareness of toxic cyanobacterial blooms in the U.S. has increased in recent years, but the substantial gaps that remain in the recognition and understanding of the risks posed by cyanobacterial cells and their toxins have hindered development of appropriate public health guidelines. These include limited data on

Table 5.1 *Examples of drinking water guidelines for cyanotoxins.*[a]

Toxin	Country	Guideline for Daily Intake
Microcystins	Australia	1.3 µg/L expressed as MC-LR toxicity equivalents
	Brazil	1 µg/L (variant not specified)
	Canada	Maximum Acceptable Concentration (MAC) of 1.5 µg/L per day for MC-LR
	Czech Republic	1 µg/L MC-LR
	France	1 µg/L of MC-LR
	New Zealand	Provisional MAC of 0.001 mg/L (= 1 µg/L) MC-LR toxicity equivalents
	Poland	1 µg/L microcystin-LR
	South Africa	Target Water Quality Range (TWQR) of 0–0.8 µg/L deemed desirable, and concentrations in excess of 1 µg/L deemed as posing a possible acute risk of hepatotoxicosis
	Spain	1 µg/L
Cylindro-spermopsins	Australia	No official guideline; however, 1 µg/L used in some areas
	Brazil	No mandatory guideline; 15 µg/L recommended value
	New Zealand	Provisional MAC of 0.001 mg/L (= 1 µg/L)
Anatoxins	New Zealand	Provisional MAC: Anatoxin 0.006 mg/L (= 6 µg/L); Anatoxin-a(s) 0.001 mg/L (= 1 µg/L)
Saxitoxins	Australia	No officially adopted guideline; "health alert" of 3 µg/L for acute exposure sometimes used for guidance
	Brazil	No mandatory guideline; 3 µg/L recommended value
	New Zealand	Provisional MAC for Saxitoxins (as STX eq) 0.003 mg/L (= 3 µg/L)

[a]Adapted from Burch, 2008.

the occurrence, frequency, and distribution of blooms and the lack of reliable analytical methods, proven prevention and mitigation technologies, and human health-risk studies (Donohue *et al.,* 2008).

Every five years the EPA is required to select a group of known or potential drinking-water contaminants for regulatory consideration. This list, known as the Contaminant Candidate List (CCL), includes contaminants about which critical information is lacking for regulatory decisions to be made. Such information can be provided by the Unregulated Contaminant Monitoring Regulation (UCMR) program, which directs select public-drinking water systems to screen for unregulated contaminants to provide insights into their occurrence and concentrations in public water supplies.

The EPA included cyanobacteria and their toxins in their first CCL published in 1998. With more than 80 variants reported, the 1998 CCL did not specify which of the cyanotoxins should be targeted for study. In February 2005, the EPA published the second CCL of 51 contaminants, again including cyanobacteria and their toxins. The EPA is currently assessing the risk of exposure to cyanotoxins: microcystins LR, RR, YR, and LA; cylindrospermopsin; and anatoxin-a and the plausibility of modeling quantitative structural-activity relationships (QSARs) for cyanotoxins. Analytical methods for cyanotoxin detection and quantification are being developed to facilitate UCMR monitoring. In the meantime, the EPA is examining the efficacy of conventional water-treatment processes for removing cyanobacteria cells and toxins from drinking-water supplies as well as exploring advanced oxidation and sonolysis techniques (Donohue *et al.,* 2008).

Recreational Waters

Recreational exposure to cyanobacteria can occur through direct skin contact or inadvertent ingestion or aspiration of algae cells or contaminated water. However, the public health effect of these exposures is poorly understood as a result of limited surveillance and human-health studies.

Australia has had recreational guidelines for cyanobacteria exposure in place since 1993. These guidelines were developed on the basis of reports that established links between skin contact with cyanobacteria and adverse health effects, especially among sensitive individuals.

In 2005, the WHO published suggested safety guidelines associated with incremental severity and probability of health effects resulting from exposure to cyanobacteria and their toxins (see Table 5.2). However, determining the acceptable concentration of blue-green algae in recreational water is more complicated. The

Table 5.2 *WHO guidelines for cyanobacterial exposure in recreational waters.*[a]

Risk Level	Guidance Level	How Level Derived	Health Risks	Typical Actions[b]
Relatively low probability of adverse health effects	20,000 cyanobacterial cells/mL or 10 µg chlorophyll *a* per L with a dominance of cyanobacteria.	Human bathing epidemiological study.	Short-term adverse health outcomes, *e.g.,* skin irritations, gastrointestinal illness.	Post on-site risk advisory signs. Inform relevant authorities.
Moderate probability of adverse health effects	100,000 cyanobacteria cells/mL or 50 µg chlorophyll *a* per L with dominance of cyanobacteria.	Provisional drinking water guideline value for MC-LR and data concerning other cyanotoxins.[c]	Potential for long-term illness with some cyanobacterial species. Short-term adverse health outcomes (*e.g.,* skin irritations, gastrointestinal illness).	Watch for scums or conditions conducive to scums. Discourage swimming and further investigate hazard. Post on-site risk advisory signs. Inform relevant authorities.
High probability of adverse health effects	Cyanobacterial scum formation in areas where whole-body contact and/or risk of ingestion or aspiration occur.	Inference from oral animal lethal poisonings. Actual human-illness case histories.	Potential for acute poisoning. Potential for long-term illness with some cyanobacterial species. Short-term adverse outcomes (*e.g.,* skin irritations, gastrointestinal illness).	Immediate action to control contact with scums; possible prohibition of swimming and other water-contact activities. Public health follow-up investigation. Inform public and relevant authorities.

[a] Excerpt from *Guidelines for Safe Recreational Water Environments,* Table 8.3, *Guidelines for Safe Practice in Managing Recreational Waters,* p. 150. (WHO, 2003).
[b] Actual action taken should be determined in light of the extent of use and a public health assessment of hazard.
[c] The provisional daily drinking-water guideline value for microcystin-LR is 1 µg/L (WHO, 1998a).

concentrations of MC-LR, any other microcystin, or the neurotoxic compounds found in blue-green algae are not currently correlated with the skin irritation and skin sensitization known to occur with exposure to blue-green algae. As in the case of the provisional drinking water guidelines, however, some countries have adopted the WHO guidelines for recreational exposure directly or with slight variations (see Appendix E).

At present there are no U.S. federal guidelines for cyanobacterial blooms in recreational waters. Water-quality criteria for recreational waters was first established in 1968 by the Department of the Interior's National Technical Advisory Committee (NTAC, 1968) and were later upheld by the EPA in 1976 and 1986 (EPA, 1986). The EPA uses fecal coliforms or enterococci as the indicator organism for evaluating the microbiological suitability of recreational water. The Healthy Beaches Act of 2000, amendment 303i to the Clean

Table 5.3 *Examples of state guidelines for cyanobacteria in recreational waters.*

State	Guideline	Control Measures
Arizona	None found	Combined monitoring efforts by Arizona Department of Environmental Quality (ADEQ), Arizona Game and Fish Department, and the University of Arizona in cooperation with the Tonto National Forest and the Arizona Department of Health Services. Monitoring includes "valley" reservoirs used for drinking water and other select water bodies. ADEQ issues press releases as deemed necessary.
California	Reference WHO guidelines based on cell counts and a toxin level of 20 µg/L	Monitoring appears to be regional with multiple agencies involved. CHDs issue press releases as deemed appropriate.
Iowa	20 ppb cyanotoxin benchmark for issuing health alerts (based on Nebraska)	Iowa State University monitors water quality in 132 lakes. The Iowa Department of Natural Resources (IDNR) and Public Health (IDPH) issue joint press releases. IDNR posts health alerts on their Web site.
Maryland	None found	Maryland Department of Natural Resources issues press releases and posts notices along water bodies as deemed necessary. The Bay Safety and Environmental Hotline was created for reporting blooms and illnesses. Illnesses associated with HABs are now reportable diseases.
Nebraska	20 ppb benchmark for issuing health alerts	In 2004, health advisories were issued for levels of 2–15 ppb, and alerts were issued at levels >15 ppb. Nebraska officials found that the two-tier system confused the public. In 2005, the state dropped the health advisories and raised the threshold for health alerts to match WHO recommendations. The Nebraska Department of Environmental Quality issues press releases and does Web-postings; e-mail notifications are sent to interested agencies; signs are posted at affected water bodies; and beaches are closed at unsafe levels.
New Hampshire	None found	Post signs at affected water body when deemed appropriate.
North Carolina	Currently developing guidelines	Monitoring animal deaths since 1990; two confirmed reports to date. Established canine surveillance program in 2005.
Minnesota	None found	Interagency workgroup (DOH, DNR, PCA, Veterinary Medical Association) formed after several dog deaths occurred in 2004.
Montana	None found	Department of Environmental Quality issues press releases as deemed necessary.
Oregon	Established mandatory guidance value of 1 µg/L for food supplements. Generally follow WHO guidelines for recreational exposure but advise against water contact when visible algae or blue or blue-green color present. Samples >15,000 cells/mL are tested for toxins.	Oregon Department of Health Services (ODHS) issues health advisory press releases and posts health advisories on their Web site. ODHS also offers a subscription service for health advisories. Signs are posted at affected water bodies.

Lake Harris

Water Act, and the November 16, 2004 federal rule change, mandated *E. coli* or enterococci as indicator organisms for freshwater beaches in the Great Lakes and enterococci only in marine waters (EPA, 2004). The 2005 International Symposium on Cyanobacterial Harmful Algal Blooms (ISOC–HAB) sponsored by federal agencies (http://www.epa.gov/cyano_habs_symposium/monograph.html) reviewed the current status regarding cyanobacteria, and the EPA is actively addressing the issue. In the absence of federal guidelines, some states have developed policies or taken other control measures to address recreational exposures to cyanobacteria and their toxins (see Table 5.3).

Blue-Green Algae Dietary Supplements

During the 2005 International Symposium on Cyanobacterial Harmful Algal Blooms, EPA officials expressed a growing concern about the potential for human exposure to cyanotoxins through the consumption of dietary supplements. Blue-green algae dietary supplements were introduced into the U.S. in 1979 and marketed for a wide range of health benefits, including weight loss, improved mental clarity, and increased energy. Blue-green algae supplements are believed to be widely used, with more than one million consumers in the U.S. and Canada.

The two primary blue-green algae species found in supplements are *Spirulina* spp. and *Aphanizomenon flos-aquae*. With no U.S. guidelines in place to monitor the safety of these products, Oregon health officials became concerned about the practice of supplement manufacturers harvesting *A. flos-aquae* from Upper Klamath Lake, where blooms of *Microcystis aeruginosa,* a hepatotoxic species, are a regular occurrence. In response to these concerns, the Oregon Health Division and the Oregon Department of Agriculture imposed a regulatory limit of 1 µg/L for microcystin content in products that contain blue-green algae (Gilroy *et al.,* 2000).

Chapter 6
Outreach Resources

Purpose *To identify resources available to conduct outreach about HABs affecting Florida through information dissemination, education, and communication activities.*

The following contains general information for creating an effective information, education, and communication (IEC) HAB activity. Information includes describing the need for IEC activities, common methods used, and materials and resources available. An additional tutorial is included on responding to media and developing an effective press release.

Information, Education, and Communication

Outreach activities related to HABs include dissemination of information, provision for education, and communication outreach. IEC is an all-encompassing expression commonly used in the health field to describe efforts to increase public awareness about a specific topic and change potentially harmful behaviors while reinforcing health-promoting practices. Critical factors to consider when initiating any IEC activity are timing (*e.g.,* season), gauging the readiness of the target audience for such a message, accessibility (*e.g.,* language or medium used), appropriateness (*e.g.,* cultural or literacy issues), relevance, resources available (*e.g.,* financial or staffing), and quality. Outreach materials should be pretested for best outcomes.

While there are a variety of reasons for conducting any outreach or health communication activity, most HAB outreach efforts focus on prevention, mitigation, and control or restoration. HAB outreach is generally done (1) to inform the public of an event in a timely manner, (2) to provide reassurance to the public that monitoring is occurring, (3) to raise awareness about possible human-health effects, and (4) to prevent unnecessary contact with potentially harmful substances or environmental components. When selecting which IEC activities to conduct in your area, it is best to first conduct a needs assessment to determine the most relevant activities given the local situation, including the level of the potential HAB threat and stakeholder attitudes.

A target audience is the group, community, or population identified as the most appropriate recipient of a particular health campaign or message. Most often the target audience for HAB information falls into one of the following categories: children, adolescents, health care providers (public and private), business owners, fishermen, life guards, the general public, tourists, and sensitive populations such as persons with respiratory conditions. The most important aspects of any outreach activity are to ensure all those potentially affected by HABs access the information.

A wide variety of materials are being used to raise awareness about HABs in Florida. For example,

- print materials—brochure, leaflet, poster, sign or billboard, fact sheet, newsletter, press kit (media package), column in newspaper, magazine, or scientific journal;
- presentations or training materials—slide presentation, poster presentation, bulletin board, curriculum or lesson plan, speech, guidelines, manual, text, or reference book;
- multimedia—public service announcement or interview on TV or radio, video, CD–ROM, DVD, GIS update, hotline, Web site; and
- promotional materials/events—button, T-shirt, sticker, magnet, frisbee, pen or pencil, health fair display, museum display.

Many IEC materials are available on the Internet. The FDOH provides a number of downloadable education and outreach materials on their ATP Web site (http://www.doh.state.fl.us/environment/community/aquatic/Education_and_Outreach_Materials.htm). Other information resources and key HAB Web sites are listed in the following sections.

Online Resources

The following list of online HAB resources is not meant to be exhaustive; however, it should serve to direct the user to key information sites from which to conduct a more comprehensive search.

Environmental and Public Health Data Sources

- Centers for Disease Control and Prevention
  http://www.cdc.gov/hab/default.htm
  - CDC National Environmental Public Health Tracking Program
    http://www.cdc.gov/nceh/tracking/resources_data.htm

START image

Red tide awareness sign

- Florida Department of Health, Aquatic Toxins Program
  http://www.doh.state.fl.us/environment/community/aquatic/index.html
- Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute
  http://research.myfwc.com/
- Mote Marine Laboratory
  http://www.mote.org
- National Oceanic and Atmospheric Administration
  http://coastwatch.noaa.gov/hab/bulletins_ns.htm
  http://www.science-house.org/nesdis/algae/background.html
- Solutions To Avoid Red Tide
  http://www.start1.com/

Links to Manuals, Powerpoint Presentations, Etc.

- Harmful Algal Research and Response: A Human Dimensions Strategy
  http://www.coastalscience.noaa.gov/stressors/extremeevents/hab/HDstrategy.pdf
- HARRNESS: The National Plan for Algal Toxins and Harmful Algal Blooms
  http://www.esa.org/HARRNESS/harrnessReport10032005.pdf
- Prevention, Control, and Mitigation of Harmful Algal Blooms: A Research Plan, September 2001 (submitted to Congress by NOAA, 2001)
  http://www.whoi.edu/science/B/redtide/pertinentinfo/PCM_HAB_Research_Plan

- Queensland Harmful Algal Bloom Response Plan, December 2002
  http://www.nrm.qld.gov.au/water/blue_green/pdf/multiagency_hab_plan_v1.pdf
- The Texas Harmful Algal Bloom Response Plan
  Copy must be requested via meridith.byrd@tpwd.state.tx.us
  http://www.tpwd.state.tx.us/landwater/water/environconcerns/hab/
- WHO Guidelines for Drinking-Water Quality
  http://www.who.int/water_sanitation_health/dwq/gdwq2v1/en/index2.html

International HAB Links

- Harmful Algae News
  http://ioc.unesco.org/hab/news.htm

This site provides links to UNESCO's publication of international news and activities concerning HABs.

- The Intergovernmental Oceanographic Commission Harmful Algal Bloom Program
  http://ioc.unesco.org/hab/

This site includes databases on HABs and health experts, IOC activities, and IOC services.

- International Atomic Energy Agency
  http://www.iaea.org/NewsCenter/Features/AlgalBloom/index.html

This site provides information and IAEA staff reports on international HAB situations—what is afflicting other countries and how they are managing.

- International Society for the Study of Harmful Algae
  http://www.issha.org/

This site provides information on HAB conferences and meetings, related proceedings and publications, and links to a variety of other HAB resources.

- State of Queensland, Australia
  http://www.nrm.qld.gov.au/water/blue_green/index.html

This site describes the state's plans and procedures for multiagency response to HABs. The site also includes multiple fact sheets related to HABs and human health.

- United Nations Educational, Scientific and Cultural Organization: Intergovernmental Oceanic Commission's Global Ecology and Oceanography of Harmful Algal Blooms
  http://www.ioc-unesco.org/hab/

This site provides information about UNESCO's HAB-related activities, research, databases, and partners.

- World Health Organization, Water-Related Diseases
  http://www.who.int/water_sanitation_health/diseases/cyanobacteria/en/

This site offers detailed information on cyanobacterial toxins, their effects on humans, and their global distribution.

Federal HAB Links

- Bigelow Laboratory for Ocean Sciences
  http://www.bigelow.org/hab/organism.html

This site provides a comprehensive overview of several types of HABs toxins and related human and animal illnesses, including toxicology and US locations of HAB species.

- CDC, Environmental Hazards and Health Effects Program (HABs)
  http://www.cdc.gov/hab/default.htm

This site includes information on various HABs and their human-health threats.

- EPA, Environmental Monitoring for Public Access and Community Tracking Program
  http://cfpub.epa.gov/si/si_public_record_Report.cfm?dirEntryID=29117

This site provides EPA's assessment of an automated biological monitoring system that measured toxicity caused by HABs in the Chicamacomico River, a tributary of Chesapeake Bay.

- Harmful Algae Management and Mitigation 2001 Conference
  http://www.cfsan.fda.gov/~frf/sfhamm.html

This site offers the conference proceedings and information on related research.

- National Institute of Environmental Health Sciences
  http://www.niehs.nih.gov/

This site offers a variety of resources including community outreach and education materials and updates on current HAB health research projects.

- NOAA, Center for Coastal Environmental Health and Biomolecular Research, Marine Biotoxins Program
  http://www.chbr.noaa.gov/default.aspx?category=mb&pageName=biotoxin

This site describes NOAA's cooperative programs, which conduct research into marine biotoxins. It includes links to federal partners, a description of research projects, and a list of publications.

- NOAA, Center for Coastal Fisheries and Habitat Research
  http://www.ccfhr.noaa.gov

This site describes NOAA's CCFHR program, which studies the effects of coastal-habitat change on living marine resources, including the effects of algal toxins.

- NOAA, Center for Sponsored Coastal Ocean Research, HABs
  http://www.cop.noaa.gov/stressors/extremeevents/hab/welcome.html
  http://www.cop.noaa.gov/products/factsheets.html

This site includes information about the program's HAB-related research activities, grants, projects, publications and partners, as well as available fact sheets. A link to NOAA's congressional mandate to establish a HAB task force and facilitate HAB investigations (HABHRCA) are found here.

- NOAA, Integrated Ocean Observing System
  http://ioos.noaa.gov/

This site describes the multidisciplinary system designed to support research and inform decision-making enhancing the ability to collect, deliver, and use ocean information in formats, rates, and scales required by scientists, managers, businesses, governments, and the public.

- Northwest Fisheries Science Center, HAB Program
  http://www.nwfsc.noaa.gov/hab/

This site describes HAB, biotoxin, and NWFSC research, and provides links to HAB newsletters and outreach materials.

- United States Environmental Protection Agency, Drinking Water Contaminant Candidate List
  http://www.epa.gov/safewater/ccl/index.html

This site provides information about EPA's list of contaminants that are not regulated, occur in public water systems, and may require regulation under the Safe Drinking Water Act. Algae that can be harmful are on this list.

- United States Food and Drug Administration, Center for Food Safety and Applied Nutrition
  http://vm.cfsan.fda.gov/~mow/chap37.html

This site provides detailed information on shellfish-associated toxins.

- Woods Hole Oceanographic Institution, National Office for Harmful Algal Blooms, The Harmful Algae Page
  http://www.whoi.edu/redtide/

This site provides facts about HABs, maps of HAB distribution across the U.S., links to information about the institution's HAB research, and PDFs of management documents.

State HAB Links

- ECOHAB Pacific Northwest
  http://www.ecohabpnw.org/

This site describes a five-year project, funded by NOAA and directed by several universities in the Pacific Northwest, to study the physiology, toxicology, ecology, and oceanography of toxic *Pseudo-nitzschia* species off the Pacific Northwest coast.

- Gulf of Mexico Coastal Observing System
  http://www-ocean.tamu.edu/GCOOS/

This site promotes establishment of a sustained observation system for the Gulf of Mexico.

- Mid-Atlantic Sea Grant Programs
  http://www.pfiesteria.seagrant.org/index.html

This site provides links to HAB-related projects funded by WHOI in New York, New Jersey, Maryland, Delaware, Virginia, and North Carolina.

- North Carolina Department of Health and Human Services, Occupational and Environmental Epidemiology program
  http://www.epi.state.nc.us

This site provides information on *Pfiesteria* and blue-green algae.

- Purdue University, Indiana: "Cyanosite"
  http://www-cyanosite.bio.purdue.edu/

This site is a purely scientific site focused on cyanobacterial taxonomy and biochemistry, but it is also an excellent source for referencing and research links.

- Wisconsin Department of Natural Resources
  http://dnr.wi.gov/lakes/bluegreenalgae/

This site addresses blue-green algae and related public health concerns. It describes the findings of a two-year monitoring program developed by the Wisconsin DNR.

Florida HAB Links

- FDEP, Bureau of Laboratories
  http://www.floridadep.org/labs/hab_info.htm

The FDEP protects, conserves, and manages Florida's natural resources and enforces the state's environmental laws. This site provides information on standard operating procedures for the collection and analysis of cyanobacterial samples.

- FDOH, Aquatic Toxins Program
  http://www.doh.state.fl.us/environment/community/aquatic/index.html

The FDOH ATP aims to protect Florida's citizens and visitors from HAB exposure or illness. This site includes information on HABs in Florida, health effects of exposure, current research, and toxins hotline number.

- FDOH, Bureau of Community Environmental Health, Food and Waterborne Illness Program
  http://www.doh.state.fl.us/environment/community/foodsurveillance/index.html

The FDOH is dedicated to prevention, monitoring and

FDOH image

Refrigerator magnet for the Aquatic Toxins Hotline

surveillance, and investigative activities related to food and waterborne illnesses, including effects of algal toxins.

- FDOH, Florida Healthy Beaches Program
  http://esetappsdoh.doh.state.fl.us/irm00beachwater/default.aspx

The FDOH performs water monitoring in coastal communities to limit threats to human health from exposure to harmful microorganisms.

- FWC–FWRI, Harmful Algal Blooms
  http://research.myfwc.com

FWRI is FWC's research division that is dedicated to protecting, conserving, and managing Florida's fish and wildlife resources by providing timely information and guidance through effective research and technical knowledge. This site offers information on HABs in Florida including basic facts, current research, bloom events, red tide status, and archives.

- MML, Red Tide
  http://www.mote.org

MML is a private, nonprofit laboratory that aids in red tide monitoring and performs a variety of related research such as developing new technology for monitoring effects on human respiratory systems and marine-policy assessments. It also produces a report of real-time beach conditions in regard to red tide along Florida's west coast.

- START, Red Tide
  http://www.start1.com

START is a non-profit organization dedicated to promoting efforts for control and mitigation of red tide in an environmentally responsible manner and committed to education outreach as its primary mitigation strategy.

- University of Miami Rosenstiel School, Oceans and Human Health Center
  http://www.rsmas.miami.edu/groups/ohh/index.htm

This site offers information on medical and ocean research conducted by U of M investigating the effects of humans on oceans and vice versa. The site provides a list of the various research projects including those related to toxic HABs.

Responding to the Press and Public

Adapted from U.S. EPA Gulf of Mexico Program report "Harmful Microalgae and Associated Public Health Risks in the Gulf of Mexico" (Steidinger and Penta, 1999)

Purpose

The purpose of a press release is to distribute consistently accurate information about an event that affects or interests the public. This assists the public in making informed decisions regarding their health and way of life.

When the public believes that an event (*e.g.,* a red tide or hurricane) threatens them, they want immediate information. All communications should address

• Who • What • When • Where • Why • How.

If an event is unusual or unexpected, immediate information may not be available, but officials must respond with as much information as is available. By providing transparent, factual information, your agency can be a valuable resource for the public. First impressions are important. The following suggestions will help when you are involved in such an event.

Preparation and Initial Response

- Prior to an event, create a plan that identifies key contacts. When an emergency situation occurs, the predesignated spokesperson should be provided with all the relevant information. Announce the identity and function of the spokesperson to your agency and to any relevant partner agencies.
- Expect media contacts before you are completely ready for them. Have an action plan that predefines communication networks, spokespersons, communication formats and other regional contacts. Tell the first inquirers that you are aware of the situation, your agency is considering how to proceed, and by a certain time a spokesperson will have information available. Always return calls and provide information—it is important to establish credibility with reporters. Even if you do not have all the information you would like, make the contact and explain what you do know at that time.
- Investigative team leaders should meet with the spokesperson and decide on guidelines about information distribution. This step will vary with the event;

it includes answering anticipated questions, listing outside referral sources, outlining a timetable of the immediate investigation, and assigning someone to research historical events of a similar nature. This will enable team members to know what is needed and assist the spokesperson in explaining what is happening to the news media and the public.

- Refer all contacts to the spokesperson. Explain to any reporter that, on a temporary basis, all contacts are going to [*insert name*] because (s)he is the only person who currently has complete and accurate information. It is crucial that the reporter be given the most reliable information. If your team is well coordinated, the spokesperson is the person with the most reliable information. A great deal of time and energy is wasted on refuting inaccurate (but usually well-intentioned) information. A disorganized effort benefits neither the agency nor the public—the agency loses credibility with the public, and the public remains confused.
- Emphasize to all team members that information MUST be sent RAPIDLY to the spokesperson. A well-informed and available spokesperson will enhance the effectiveness of the research team because the team will have more time to focus on the scientific investigation.

On-Going Events

The first few days are often characterized by numerous inquiries about the status of the event; the spokesperson will probably spend a great deal of time responding to these inquiries and receiving new information. However, after the initial deluge of information requests, the spokesperson is often more effective as someone who summarizes incoming information and disperses it to a number of interested parties, who then redistribute it as needed. For example, the spokesperson can e-mail a daily status report to other government agencies, regulatory commissions, government officials, or media sources. Timely Web site updates can also be useful in disseminating crucial information.

Giving the public access to accurate information will relieve some of the burden for the initial investigating agency because questions can be answered by remote sources instead of being referred to the primary agency and spokesperson. It also keeps misinformation to a minimum.

The obvious disadvantage to this type of arrangement is that some incorrect information may be introduced. However, the advantages of providing useful information and generating goodwill with partner agencies generally outweigh the disadvantages of occasional misinformation.

Employees should always refer callers to the contact listed on the status report, especially if they cannot answer specific questions. Agency managers must emphasize to their employees that information should only be provided when the information has been confirmed; if the employee is not certain, the inquiry should be referred to someone who has relevant information. Other useful communication tools include the following:

- Frequently Asked Questions (FAQs) sheets for anyone who answers incoming calls (see http://www.myfloridaeh.com, under Aquatic Toxins; see Figure 6.5).
- Brochures that can be left at various locations (*e.g.*, piers, bait houses, hotels) or distributed to local agencies such as Chambers of Commerce (see http://www.myfloridaeh.com, under Aquatic Toxins; see Figure 6.6).
- Fact Sheets that can be easily generated in-house via desktop publishing systems to meet unexpected or rapidly changing needs (see http://www.myfloridaeh.com, under Aquatic Toxins).

Developing an Effective Press Release

News releases may be generated as needed. Although press releases are useful tools used by many organizations to announce new initiatives, research results, and status reports that are newsworthy, they may not be effective for unusual, on-going events like HABs. Their overall effectiveness in these situations is debatable. Possible reasons for this argument include the following.

- Within governmental agencies, it often requires hours (sometimes as many as 24–48 hours) to prepare and process a release through the necessary managerial and scientific approvals. If any of these approvals are bypassed for expediency, the release may suffer and convey inaccurate information.
- Reporters rarely use only the release information; they usually make a personal contact. Staff time is required for both release preparation and follow-up explanation.

The following examples demonstrate how a poor press release can be effectively improved using a few simple guidelines. Figures 6.1–6.4 are examples of various types of HAB-related public health releases issued between 2003 and 2006, including new releases, press releases, and health advisories.

Example of a Poor Press Release

PROPOSED PRESS RELEASE

Gulf coast beaches are currently being affected by a red tide. Red tides have occurred in Florida since the 1500s. They cause fish kills and respiratory irritation and have been known to last as long as 18 months. Red tides may occur in places other than Florida; in fact, those in New England and off California and Alaska have been responsible for the deaths of marine animals and humans. The Florida Department of Agriculture and Consumer Services has closed shellfish-harvesting areas along the entire southwest coast of Florida until further notice.

HOW CAN THIS RELEASE BE MORE EFFECTIVE?

- Always answer who, what, when, where, why, and how.
- Present specific information about the current event. Indicate what occurred (fish kills, water discoloration, respiratory irritation), where and when it occurred, and who is responding. Example: On Saturday morning, hundreds of dead mullet and catfish washed ashore on St. Pete Beach. FWC researchers responded to investigate the cause of the fish kill.
- Identify the effect on the public. Health effects are generally the public's (and reporter's) first concern. How humans are affected (*e.g.,* ingestion of contaminated seafood, respiratory irritation, aesthetics of dead fish and smell) should be clearly identified.
- Avoid alarmist and irrelevant information. Stick to the facts about this occurrence. Provide common sense, nonalarmist information.
- Provide only necessary, uncontroversial and well-documented information. Be prepared to provide historical, supplementary information for those reporters who do in-depth or human-interest articles.
- Avoid speculation—it can be misleading.
- Press releases should always include the name and phone number of a contact person.
- Quotes are building blocks for news stories. Reporters prefer press releases that contain at least one quote by a reliable source from the distributing agency.

Example of a Good Press Release

[*insert date*]

[*insert headline*]

Contact: [*insert name*] [*insert phone number*]

Hundreds of dead mullet and catfish washed ashore on St. Pete Beach Monday morning, prompting the Florida Department of Agriculture and Consumer Services (FDACS) to close local shellfish harvesting areas as researchers from the Florida Fish and Wildlife Conservation Commission's (FWC) Fish and Wildlife Research Institute (FWRI) pointed to Florida's red tide as the cause.

"Laboratory tests on the St. Pete Beach water samples we took showed that cell counts of the red tide organism were much higher than normal and were high enough to cause fish kills," said [*insert name*], [*insert title*].

The southwest Florida coast is no stranger to red tides, a natural phenomenon caused by the tiny alga called *Karenia brevis* (*K. brevis*). Florida red tides have been reported for over 160 years and thought to date back to the 1500s. They usually start offshore, occur in the late summer or fall, and last only a few months. *K. brevis* is always present in Gulf waters in low concentrations, but when it blooms or grows in patches with higher-than-normal concentrations, a red tide occurs.

The shellfish harvesting ban from Tarpon Springs to Charlotte Harbor means you should not eat regulated shellfish (hard clams, oysters, coquinas) or other mollusks from these areas. They accumulate red tide toxin (brevetoxin), which may cause various levels of gastrointestinal and neurological distress in those who eat them. Asthma sufferers and those with other respiratory problems are also urged to stay away from beaches in these areas because respiratory discomfort may be associated with red tides.

It is too early to tell how this red tide event compares to the other red tides Florida has experienced, FWC officials said Monday afternoon. FWC researchers will continue monitoring offshore and inshore waters. FDACS will lift the harvesting ban when FWC laboratory tests show that the shellfish are safe to eat, [*insert name*] said.

For more information about Florida red tide, visit the Florida Department of Health Aquatic Toxins Web site at www.myfloridaEH.com or the FWRI Web site at http://research.MyFWC.com.

Lee issues advisory to avoid red-tide shellfish

By Michelle L. Start
mstart@news-press.com
Originally posted on July 19, 2006

The Lee County Health Department is warning people to stay away from red-tide contaminated shellfish after 11 visitors became ill from eating clams they harvested this month.

No local residents have become sick.

Officials said six of the people were so ill they were admitted to hospital intensive care units and the neurotoxic outbreak constitutes an epidemic.

Symptoms of the illness include numbness, tingling in the extremities, gastrointestinal symptoms and difficulty speaking and walking. People who experience these symptoms after ingesting contaminated shellfish should seek medical care immediately.

"These were people visiting here on vacation who were catching their own clams and cooking them," said Lee County Health Department Director Dr. Judith Hartner. "So far, they have only been harvesting and eating clams, but people should also avoid mussels, oysters and scallops if you can find them."

Lee County Visitor and Convention Bureau Deputy Director Tamara Pigott said it is nearly impossible to measure the impact the outbreak will have on tourism.

Hartner said the neurotoxic outbreak can be traced to red tide, which is caused by the organism *Karenia brevis,* or *K. brevis.*

"Even when the algae is in very low concentrations, it can still contaminate the shellfish, which concentrate the toxins in their bodies," she said.

Pigott said the bureau is distributing the health department's notice and hoteliers are sharing the information with guests.

"Visitors are not educated about our waters," she said. "Locally, we're very aware of red tide. We don't harvest shellfish and we know we're not supposed to eat them during red tide."

Eating shellfish at restaurants is safe, officials said.

Of the 11 people sickened, 10 became ill with clams gathered in Sanibel.

Sanibel is delivering notices to every home, calling every listed telephone number, distributing fliers at the bridge and giving out notices at the visitor center.

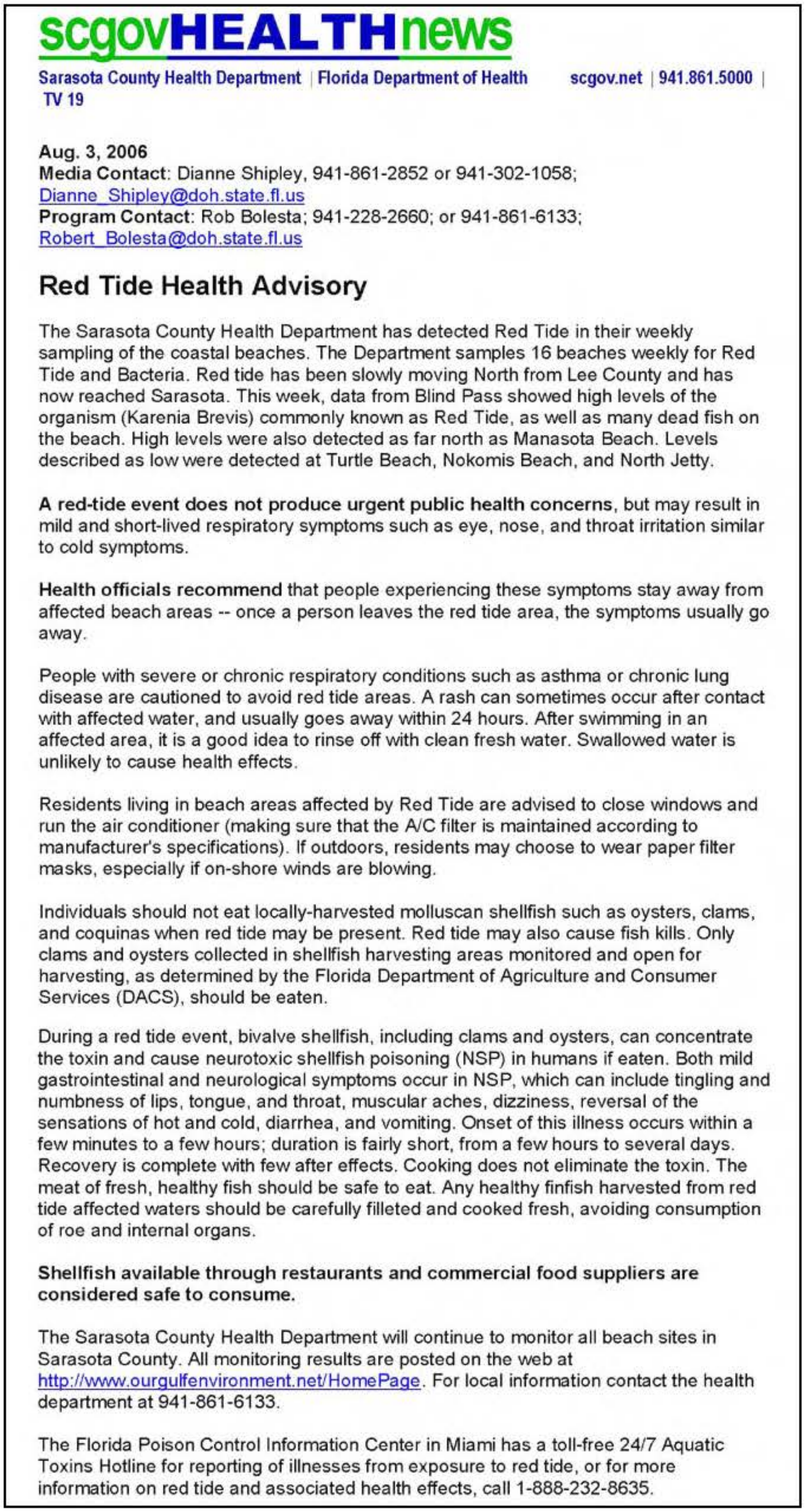
The other case was at Fort Myers Beach.

Beach Seafood Market owner Dennis Henderson said he worried the outbreak could have an impact on his business, although it shouldn't.

"All of the people we buy clams from and even the one outfit here in Pine Island are regulated by the state," said Henderson, whose market is located on Shrimp Boat Lane in Fort Myers Beach. "They do quality checks on the beds every week. When there is red tide, they have other beds upstate and in the Panhandle where they harvest. I know what we get is safe."

He said those looking to purchase shellfish should buy from a licensed vendor.

Figure 6.1 *Example 1—Sample news release.*



scgovHEALTHnews

Sarasota County Health Department | Florida Department of Health scgov.net | 941.861.5000 | TV 19

Aug. 3, 2006
Media Contact: Dianne Shipley, 941-861-2852 or 941-302-1058; Dianne_Shipley@doh.state.fl.us
Program Contact: Rob Bolesta; 941-228-2660; or 941-861-6133; Robert_Bolesta@doh.state.fl.us

Red Tide Health Advisory

The Sarasota County Health Department has detected Red Tide in their weekly sampling of the coastal beaches. The Department samples 16 beaches weekly for Red Tide and Bacteria. Red tide has been slowly moving North from Lee County and has now reached Sarasota. This week, data from Blind Pass showed high levels of the organism (Karenia Brevis) commonly known as Red Tide, as well as many dead fish on the beach. High levels were also detected as far north as Manasota Beach. Levels described as low were detected at Turtle Beach, Nokomis Beach, and North Jetty.

A red-tide event does not produce urgent public health concerns, but may result in mild and short-lived respiratory symptoms such as eye, nose, and throat irritation similar to cold symptoms.

Health officials recommend that people experiencing these symptoms stay away from affected beach areas -- once a person leaves the red tide area, the symptoms usually go away.

People with severe or chronic respiratory conditions such as asthma or chronic lung disease are cautioned to avoid red tide areas. A rash can sometimes occur after contact with affected water, and usually goes away within 24 hours. After swimming in an affected area, it is a good idea to rinse off with clean fresh water. Swallowed water is unlikely to cause health effects.

Residents living in beach areas affected by Red Tide are advised to close windows and run the air conditioner (making sure that the A/C filter is maintained according to manufacturer's specifications). If outdoors, residents may choose to wear paper filter masks, especially if on-shore winds are blowing.

Individuals should not eat locally-harvested molluscan shellfish such as oysters, clams, and coquinas when red tide may be present. Red tide may also cause fish kills. Only clams and oysters collected in shellfish harvesting areas monitored and open for harvesting, as determined by the Florida Department of Agriculture and Consumer Services (DACS), should be eaten.

During a red tide event, bivalve shellfish, including clams and oysters, can concentrate the toxin and cause neurotoxic shellfish poisoning (NSP) in humans if eaten. Both mild gastrointestinal and neurological symptoms occur in NSP, which can include tingling and numbness of lips, tongue, and throat, muscular aches, dizziness, reversal of the sensations of hot and cold, diarrhea, and vomiting. Onset of this illness occurs within a few minutes to a few hours; duration is fairly short, from a few hours to several days. Recovery is complete with few after effects. Cooking does not eliminate the toxin. The meat of fresh, healthy fish should be safe to eat. Any healthy finfish harvested from red tide affected waters should be carefully filleted and cooked fresh, avoiding consumption of roe and internal organs.

Shellfish available through restaurants and commercial food suppliers are considered safe to consume.

The Sarasota County Health Department will continue to monitor all beach sites in Sarasota County. All monitoring results are posted on the web at http://www.ourgulfenvironment.net/HomePage. For local information contact the health department at 941-861-6133.

The Florida Poison Control Information Center in Miami has a toll-free 24/7 Aquatic Toxins Hotline for reporting of illnesses from exposure to red tide, or for more information on red tide and associated health effects, call 1-888-232-8635.

Figure 6.2 *Example 2—Sample health advisory/press release.*

FLORIDA DEPARTMENT OF
HEALTH

Jeb Bush
Governor

John O. Agwunobi, M.D., M.B.A.
Secretary

News Release • News Release • News Release • News Release

For Immediate Release
August 12, 2005

Contact: Patricia Frank, RN
Public Information Officer
630-3254

Health Alert Health Alert Health Alert

Jacksonville, FL - August 12, 2005, the St. Johns Water Management District has tested the St. Johns River for toxins resulting from the blue-green algae bloom. The test results indicate high concentrations of toxin. The bloom affects the river in Duval County and extends through Clay and St. Johns Counties.

Health effects can occur when surface scum or water containing high levels of blue-green algal toxins are swallowed, through contact with the skin or when airborne droplets containing toxins are inhaled while swimming, bathing or showering. Direct contact or breathing airborne droplets containing high levels of algal toxins during swimming or showering can cause irritation of the skin, eyes, nose and throat and inflammation in the respiratory tract.

The Health Department recommends people refrain from recreational use of the river this weekend that could result in ingestion of and/or skin exposure to river water. Children should also not be allowed to play along the shoreline where they might be exposed to clumps of algae or drink water from the river. It is unclear as to whether ingestion of fish from the river poses a health risk.

Livestock and pet deaths have occurred when animals consume large amounts of accumulated algal scum from along shorelines. Do not allow pets to eat clumps of algae that accumulate along the shoreline.

The River Water Management District will retest the affected areas on Monday.

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Duval County Health Department

Public Information Office • MC-29 • 515 West Sixth Street • Jacksonville, Florida • 32206-4397 • (904) 630-3254

In partnership with the City of Jacksonville

Figure 6.3 *Example 3—Sample health advisory/press release.*

FLORIDA DEPARTMENT OF HEALTH

Jeb Bush
Governor

John O. Agwunobi, M.D., M.B.A.
Secretary

FOR IMMEDIATE RELEASE
April 30, 2003

Contact: Rob Hayes
850-245-4111

STATEMENT FROM DEPARTMENT OF HEALTH SECRETARY REGARDING THE CONSUMPTION OF PUFFER FISH

TALLAHASSEE—The Florida Department of Health (DOH) is currently investigating two suspected food poisoning cases that may be related to the consumption of puffer fish (also called blowfish) caught off the Atlantic Coast of Florida.

"It is important for people to understand that cooking the fish cannot destroy the toxin. The message is simple, yet serious. There is a health risk associated with the consumption of puffer fish," said DOH Secretary John O. Agwunobi, MD, MBA.

Neurotoxin Facts

Neurotoxin poisoning develops fairly rapidly after the consumption of the contaminated fish, within ½ - 2 hours, depending on the amount of toxin consumed.

Symptoms

Symptoms are primarily neurological and include: tingling, burning, numbness, drowsiness, incoherent speech, and respiratory paralysis. It is also possible to experience nausea and vomiting. In severe cases, poisoning can cause death.

Treatment

If you experience neurological symptoms as described above and have consumed puffer fish, please contact your physician or emergency room immediately.

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4052 Bald Cypress Way • Tallahassee, FL 32399-1701

Figure 6.4 *Example 4—Sample health advisory/press release.*

FLORIDA DEPARTMENT OF HEALTH

DIVISION OF Environmental Health

Frequently Asked Questions About Florida Red Tide and Their Toxins

Q: What is Florida Red Tide?
A: In Florida, red tide is caused by microscopic algae (plant-like microorganism) called *Karenia brevis* or *K. brevis*. The organism produces a toxin that can affect the central nervous system of fish, birds, mammals and other animals.

Q: Is Florida Red Tide, Red?
A: At high concentrations (called blooms), the organisms may discolor the water – sometimes red, light or dark green brown or clear.

Q: Where does Florida Red Tide occur?
A: Red tides or Harmful Algal Blooms occur worldwide. *K. brevis* is found almost exclusively in the Gulf of Mexico but has been found on the east coast of Florida and off the coast of North Carolina.

Q: How long does it last?
A: Red tide blooms can last days, weeks or months and can also change daily due to wind conditions. Onshore winds normally bring it near the shore and offshore winds drive it out to sea.

Q: What causes Florida Red Tide?
A. A red tide bloom needs biology (the organisms), chemistry (natural or man-made nutrients for growth), and physics (concentrating and transport mechanisms). No one factor causes it. Tests are being conducted to see if coastal nutrients enhance or prolong blooms.

Q: Can I swim in water affected by Florida Red Tide?
A: Most people can swim in red tide but it can cause skin irritation and burning eyes. If your skin is easily irritated, avoid red tide water. If you experience irritation, get out and thoroughly wash off with fresh water. Swimming near dead fish is not recommended.

Q: What are the symptoms I can get from Florida Red Tide?
A: Symptoms from breathing red tide toxins are normally coughing, sneezing and teary eyes. These are usually temporary when red tide toxins are in the air. Wearing a particle filter mask may lessen the affects, and using over-the-counter antihistamines may decrease your symptoms. Check the marine forecast. Fewer toxins are in the air when the wind is blowing offshore.

(continued next page)

Figure 6.5 *Example 5—Frequently asked questions about Florida red tide and their toxins.*

Q: Are there people who are more sensitive to the toxins?
A: People with respiratory problems (like asthma or bronchitis) should avoid red tide areas, especially when winds are blowing toxins onto the shore. If you go to the beach, take your short acting inhaler with you. If you have symptoms, leave the beach and seek air conditioning.

Q: Who do I call if I get sick from Florida Red Tide?
A: You can call the Aquatic Toxins toll free hotline at 1-888-232-8635. It is staffed 24/7 by medical professionals. If symptoms are severe, call your local doctor.

Q: Can I eat seafood at restaurants during a Florida Red Tide?
A: Commercial seafood found in restaurants and grocery stores is safe because it comes from red tide free water and is monitored by the government for safety.

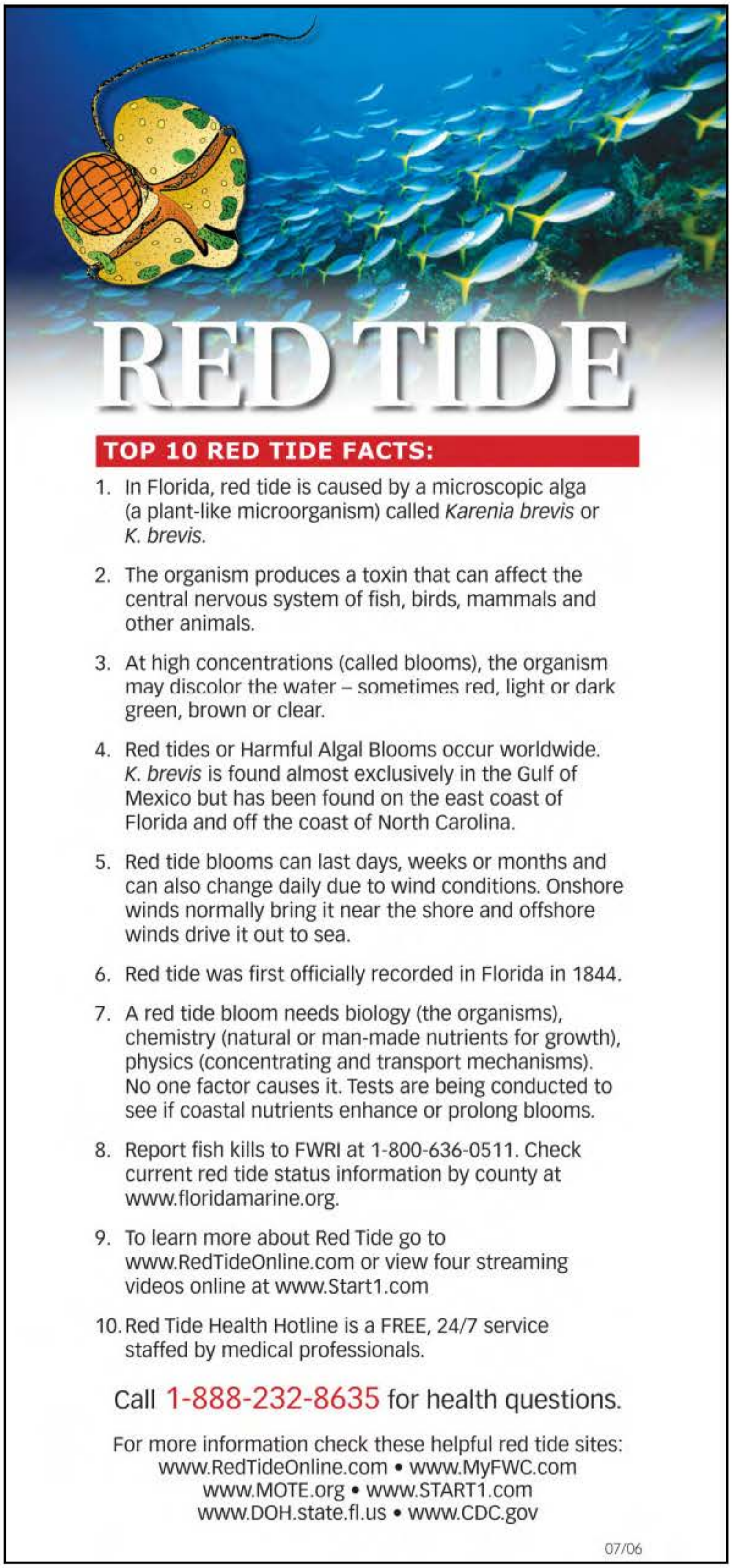
Q: Can I eat seafood from recreational harvesting during a Florida Red Tide?
A: Recreational fisherman must be careful:

Do not eat mollusks (clams or oysters taken from Florida red tide waters, as they contain toxins that cause a food poisoning called NSP (Neurotoxic Shellfish Poisoning). Finfish caught live and healthy can be eaten if filleted.

Use common sense! Harvesting distressed or dead animals is not advised under any circumstances. Edible parts of other animals commonly called shellfish (crabs, shrimp and lobsters), are not affected by the red tide organisms and can be eaten. Do not eat the tamale (green stuff, hepatopancreas).

Q: Are there web sites for more information about Florida Red Tide?
A:
www.RedTideOnline.com
www.MyFWC.com
www.MOTE.org
www.START1.com
www.MyFloridaEH.com

Figure 6.5 *Example 5—Frequently asked questions about Florida red tide and their toxins. (continued)*



RED TIDE

TOP 10 RED TIDE FACTS:

1. In Florida, red tide is caused by a microscopic alga (a plant-like microorganism) called *Karenia brevis* or *K. brevis*.
2. The organism produces a toxin that can affect the central nervous system of fish, birds, mammals and other animals.
3. At high concentrations (called blooms), the organism may discolor the water – sometimes red, light or dark green, brown or clear.
4. Red tides or Harmful Algal Blooms occur worldwide. *K. brevis* is found almost exclusively in the Gulf of Mexico but has been found on the east coast of Florida and off the coast of North Carolina.
5. Red tide blooms can last days, weeks or months and can also change daily due to wind conditions. Onshore winds normally bring it near the shore and offshore winds drive it out to sea.
6. Red tide was first officially recorded in Florida in 1844.
7. A red tide bloom needs biology (the organisms), chemistry (natural or man-made nutrients for growth), physics (concentrating and transport mechanisms). No one factor causes it. Tests are being conducted to see if coastal nutrients enhance or prolong blooms.
8. Report fish kills to FWRI at 1-800-636-0511. Check current red tide status information by county at www.floridamarine.org.
9. To learn more about Red Tide go to www.RedTideOnline.com or view four streaming videos online at www.Start1.com
10. Red Tide Health Hotline is a FREE, 24/7 service staffed by medical professionals.

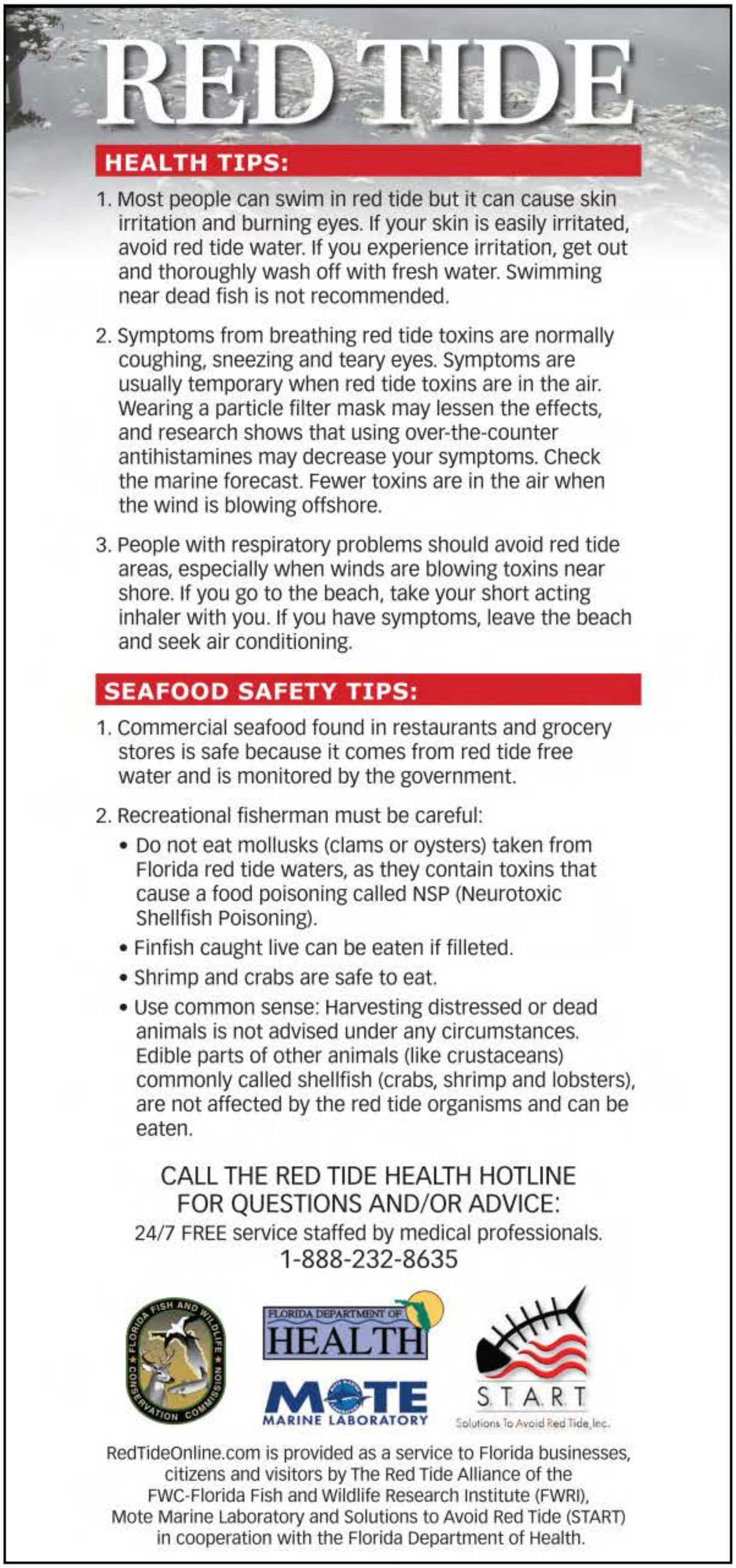
Call 1-888-232-8635 for health questions.

For more information check these helpful red tide sites:
www.RedTideOnline.com • www.MyFWC.com
www.MOTE.org • www.START1.com
www.DOH.state.fl.us • www.CDC.gov

07/06

Red Tide Alliance image

Figure 6.6 *Example of red tide facts handout, side 1.*



RED TIDE

HEALTH TIPS:

1. Most people can swim in red tide but it can cause skin irritation and burning eyes. If your skin is easily irritated, avoid red tide water. If you experience irritation, get out and thoroughly wash off with fresh water. Swimming near dead fish is not recommended.

2. Symptoms from breathing red tide toxins are normally coughing, sneezing and teary eyes. Symptoms are usually temporary when red tide toxins are in the air. Wearing a particle filter mask may lessen the effects, and research shows that using over-the-counter antihistamines may decrease your symptoms. Check the marine forecast. Fewer toxins are in the air when the wind is blowing offshore.

3. People with respiratory problems should avoid red tide areas, especially when winds are blowing toxins near shore. If you go to the beach, take your short acting inhaler with you. If you have symptoms, leave the beach and seek air conditioning.

SEAFOOD SAFETY TIPS:

1. Commercial seafood found in restaurants and grocery stores is safe because it comes from red tide free water and is monitored by the government.

2. Recreational fisherman must be careful:
   - Do not eat mollusks (clams or oysters) taken from Florida red tide waters, as they contain toxins that cause a food poisoning called NSP (Neurotoxic Shellfish Poisoning).
   - Finfish caught live can be eaten if filleted.
   - Shrimp and crabs are safe to eat.
   - Use common sense: Harvesting distressed or dead animals is not advised under any circumstances. Edible parts of other animals (like crustaceans) commonly called shellfish (crabs, shrimp and lobsters), are not affected by the red tide organisms and can be eaten.

CALL THE RED TIDE HEALTH HOTLINE
FOR QUESTIONS AND/OR ADVICE:
24/7 FREE service staffed by medical professionals.
1-888-232-8635

RedTideOnline.com is provided as a service to Florida businesses, citizens and visitors by The Red Tide Alliance of the FWC-Florida Fish and Wildlife Research Institute (FWRI), Mote Marine Laboratory and Solutions to Avoid Red Tide (START) in cooperation with the Florida Department of Health.

Red Tide Alliance image

Figure 6.6 *Example of red tide facts handout, side 2.*

Chapter 7

Management Strategies for Mitigation of HABs

Purpose *To describe management strategies for mitigating HABs in Florida.*

The following contains general background information describing HAB mitigation activities such as prevention and reduction of human exposures and reduction of bloom activity. Activities may include research aimed at bloom prevention or control or mitigation through information dissemination such as issuing press releases or health advisories to increase public awareness of an event and reduce adverse human exposures.

Mitigation Activities

Mitigation can be defined as "…minimizing HAB impacts on human health, living resources, and coastal economies when they do occur…"(NOAA, 2001). These activities can take place before, during, or after an event. Specific measures designed to address each stage of a HAB event should be identified and combined with ongoing actions or "preparedness." CHDs should identify a local focal person to coordinate work with various statewide agencies conducting mitigation activities.

Various management strategies for the mitigation of HABs exist from activities aimed at preventing and physically controlling blooms to activities focused on reducing the negative effects of HABs and their toxins on environmental and human health. Prevention strategies are used to avoid the occurrence of, or minimize exposure to, HABs. Presently, strategies for preventing "events" are limited. Research is focused on determining the technological feasibility of enhancing HAB prevention capabilities statewide. Additional prevention activities include regulating nutrient inputs from human land-based activities to minimize bloom growth and regulating ballast water releases to reduce HAB introductions or global expansion. HAB control strategies include activities to reduce or contain the bloom populations or their effects, and involve direct interventions during HAB events for the purpose of eliminating toxic or harmful cells or inhibiting their growth. As with prevention strategies, many control strategies are being tested for their effectiveness and their effects on the environment. Such strategies include mechanical, chemical, and biological control methods. Examples of control methods to remove cells or toxins include using pumps and filters, clay flocculation, or introducing natural predators such as parasites (Sengco, 2009).

Other HAB mitigation strategies being used focus on monitoring, forecasting, and early detection or warning systems; analysis of hazard-related data; and information dissemination (Heil and Steidinger, 2009). Mitigation emphasis is on the education of government entities, private sector businesses, and the general public regarding measures they can all take to reduce harmful effects. Modeling and forecasting are used to provide a system for predicting HABs such as Florida red tides. With these predictions, shellfish harvesting areas can be selectively monitored, the public can plan ahead, and regulatory agencies, local governments, and businesses can implement contingency plans (Heil, 2009). Monitoring beaches and harvesting areas to allow warning of outbreaks such as red tide cough or food poisoning incidents promotes public safety and is the most effective mitigation method to date. HAB education is crucial for raising awareness about the health risks associated with shellfish consumption and beach-going, and on the environmental effects of blooms on aquatic ecosystems.

The FDOH, through CHDs, issues health advisories based on local needs. Press releases are the mechanism through which most CHDs disseminate information on health risks related to current HAB events. Press releases are usually picked up by local media outlets including television, newspapers, and radio. In some cases, national media has also used these releases to report on conditions. In rare instances, the FDOH Central Office has issued press releases (see Outreach Resources Chapter 6 for examples of health advisories and press releases).

Methods for restoring damaged aquatic resources after bloom dissipation are also being investigated as a final step in the mitigation of HAB events. Restoration involves returning the site to its pre-bloom status. Restoration activities include testing and reopening shellfish beds, cleaning up beaches by removing dead fish or other animal carcasses, or relocating and reha-

FWC image

Beach cleanup of dead fish following a red tide

bilitating affected animals. Currently, carcasses from massive fish kills are relocated to landfills or buried under tons of sand with bulldozers; this is usually done by local governments. The development of strategies to remove and safely dispose of dead fish and other species is necessary because recreational activities are dependent on aesthetically clean beaches and a healthy coastline environment.

The FDACS has identified four possible mitigation strategies for managing shellfish harvesting areas threatened by *K. brevis* blooms, including reclassifying new areas for separate monitoring and management, and periodic random brevetoxin testing of hard-clam processing facilities and lease areas for potentially limited quarantine (Heil, 2009).

The Red Tide Control and Mitigation Program

In 2006 the Florida Legislature provided a recurring general revenue appropriation of $4,014,449 to FWC–FWRI to support red tide research. The legislative funds were dedicated as supplementary funds following a $4.73 million award from NOAA's ECOHAB program to investigate the role of nutrients in bloom dynamics and possible causes of red tide blooms. The Florida statute, 379.2272 (formerly 370.06093), charges FWRI with implementing "a program designed to increase the knowledge of factors that control harmful algal blooms, including red tide, and to gain knowledge to be used for the early detection of factors precipitating harmful algal blooms for accurate prediction of the extent and seriousness of harmful algal blooms and for undertaking successful efforts to control and mitigate the effects of harmful algal blooms.... The goal of this program is to enable resource managers to assess the potential for public health damage and economic damage from a given bloom and to undertake control and mitigation efforts through the development and application of an integrated detection and prediction network for monitoring and responding to the development and movement of harmful algal blooms in Florida marine and estuarine waters."

Of the appropriated funds, $1,000,000 was designated directly to the Red Tide Control and Mitigation Program. The majority of these funds are granted to research efforts directed towards environmentally friendly techniques or technologies for controlling or reducing the spatial and temporal coverage of Florida red tide blooms caused by *K. brevis*; controlling or reducing the toxicity of *K. brevis;* and minimizing the effects of Florida red tide on public health, environmental health, and natural resources. Other mitigation strategies focus on reducing the economic and social effects of Florida red tide blooms. These funds are disbursed annually to a variety of researchers, including government entities, universities, and other organizations involved with HAB research on the economic, social, environmental, natural-resource, and public-health effects of red tides. However, legislative budget cuts that began in 2008 threaten the program's future.

Chapter 8
Research Needs

Purpose *To identify priority research and policy needs for HABs in Florida.*

There is a world-wide effort to monitor and assess the ecological and public health effects of HABs. Many countries and their governmental agencies, along with a multitude of research and development facilities, are developing analytical laboratory methods and rapid field kits for phycotoxin detection, conducting epidemiological studies on the effects of HABs and their toxins on humans and natural resources, conducting ecological and molecular surveys to identify HABs and their toxin distribution in biota, and performing in vivo and in vitro toxicology studies through biological assays. There are international and national perspectives regarding the focus on specific HAB species, but many of these efforts have direct application to HABs occurring in Florida.

The following list (in no specific order) summarizes some priority public health research and policy needs for HABs in Florida as identified in the accompanying resources.

Florida HAB Public Health Research Needs

Clinical

There are few methodologies to document exposures to HAB-related toxins. The need for the identification of human biomarkers related to dose and response are just beginning to be recognized. There is a crucial need to determine the relationship between exposure dose and adverse health outcomes and illness.

- Develop tools for clinical diagnostic support including urine and blood tests.
- Assess the potential of algal toxin exposures to cause acute and long-term health effects.

Human and Animal Surveillance

In order to assess public health impacts related to HABs, it is imperative to develop tools to identify HAB-associated cases from a variety of sources, including hospitals, emergency departments, stand-alone clinics, general practitioners, and entities other than traditional health care providers. This effort will include the partnering of the FDOH Central Office and local CHDs with health care providers, other agencies with community contacts, and specific ethnic entities that are outside of the usual public health lines of communication. The use of animals as sentinel systems is also relevant and has a number of public health precedents in outbreak response and mitigation.

- Provide reportable disease training to health care providers that includes NSP, PSP, SPFP, and CFP.
- Develop early-warning systems and identify sentinel animal species that can be used to minimize human exposure to biotoxins.
- Assess community vulnerability to HAB-associated public health risks.
- Improve data-sharing capabilities for identifying HAB-related disease outbreaks.

Environmental

The ability to assess ecological conditions associated with the development and persistence of HABs is essential to gaining a better understanding of their potential to affect human health. The presence of toxins at very low levels is just beginning to be appreciated for their potential chronic health effects. Methods to prevent and mitigate the effects of HABs and their toxins on humans can be greatly improved by epidemiological and environmental studies and through predictive modeling.

- Improve monitoring, detection, and documentation of the occurrence of cyanotoxins in drinking and recreational waters.
- Determine what environmental or genetic factors stimulate toxicity in HABs.
- Determine to what extent HAB toxins accumulate in the food chain.
- Determine whether aquatic animals and/or humans are at risk if exposed to cyanotoxins.
- Determine whether cyanotoxins have prolonged effects on aquatic habitats.
- Conduct research on possible adverse effects of current water treatment methods and control measures for cyanobacterial HABs (*e.g.,* variability in toxin production and possible toxin production from spraying chemical treatment).
- Develop effective mitigation and control efforts for
  - the removal of toxins from drinking water sources and recreational systems, and

- ◦ improved control and treatment methods for affected waters.
- Assess the public health threat from other known (but minimally studied) HAB genera in Florida (*e.g., Cylindrospermopsis, Prorocentrum*).
- Assess public health risks associated with the recreational harvesting in closed areas of shellfish species that have become toxic from red tide and other Florida HAB endemic species (*i.e., K. brevis, P. bahamense*).

Laboratory

Our understanding of both the ecology and public health effects of HABs have been greatly enhanced due to improvements in analytical and molecular methodologies for studying the environment. Automated instrumentation, simplified molecular probes, and establishment of consistent detection and quantitation limits have resulted in the determination of environmental concentrations of toxins, identification of HAB organisms implicated in toxin production, and analysis of how the affected biota can further affect public health. Further refinement of existing technologies, together with the development of innovative new procedures, will enable faster detection of HABs and their toxins and lead to better response capability.

- Incorporate validated and rapid field and/or laboratory detection methods for the following:
  - Cyanotoxins: enzyme-linked immunosorbent assay (ELISA) tests dramatically increased the ability of laboratories to detect cyanotoxins. However, these are not universally available for all important cyanotoxins. Standardized methods and interlaboratory calibration procedures are needed to ensure the reliability and validity of results.
  - Saxitoxins: Although rapid methods for STX analyses are available, few Florida laboratories have the sophisticated capabilities required for definitive confirmation. Recent development of an easy-to-use molecular assay (ELISA) should allow increased evaluation of both animal and plant tissue.
  - Brevetoxins: Currently, MBA is the only method approved for detecting NSP toxins, and state and federal governments require this information in order to regulate the closing and reopening of shellfish beds for harvest. The ELISA molecular technique for detecting these toxins needs further development and documentation to support its use as a rapid and more cost-effective tool for shellfish regulation and management.
  - Ciguatera: Currently only federal laboratories can do confirmative testing; enhanced capabilities in state laboratories are desirable. This would allow faster and better identification of ciguatoxic fish or reefs at risk and reduce the chance of affected fish entering the food supply.
- Develop automated methods for organism identification: the use of molecular probes would make identification of HAB species much easier. These techniques, as well as automated toxin assays, may be possible to incorporate into automated instruments to assess environmental samples remotely.

Public Health Policy Needs, Applications for HAB Research

- Develop action levels for the presence of algal toxins and incorporate them into water-quality standards for both drinking and recreational waters.
- Develop county-specific response plans addressing pertinent HABs to protect public health.
- Develop effective outreach and education efforts to increase public awareness of and medical proficiency in the treating of HAB-related illness.
- Assess the need to distribute and ability to maintain proper and consistent signage to inform the public of HAB events.

Identified Resources

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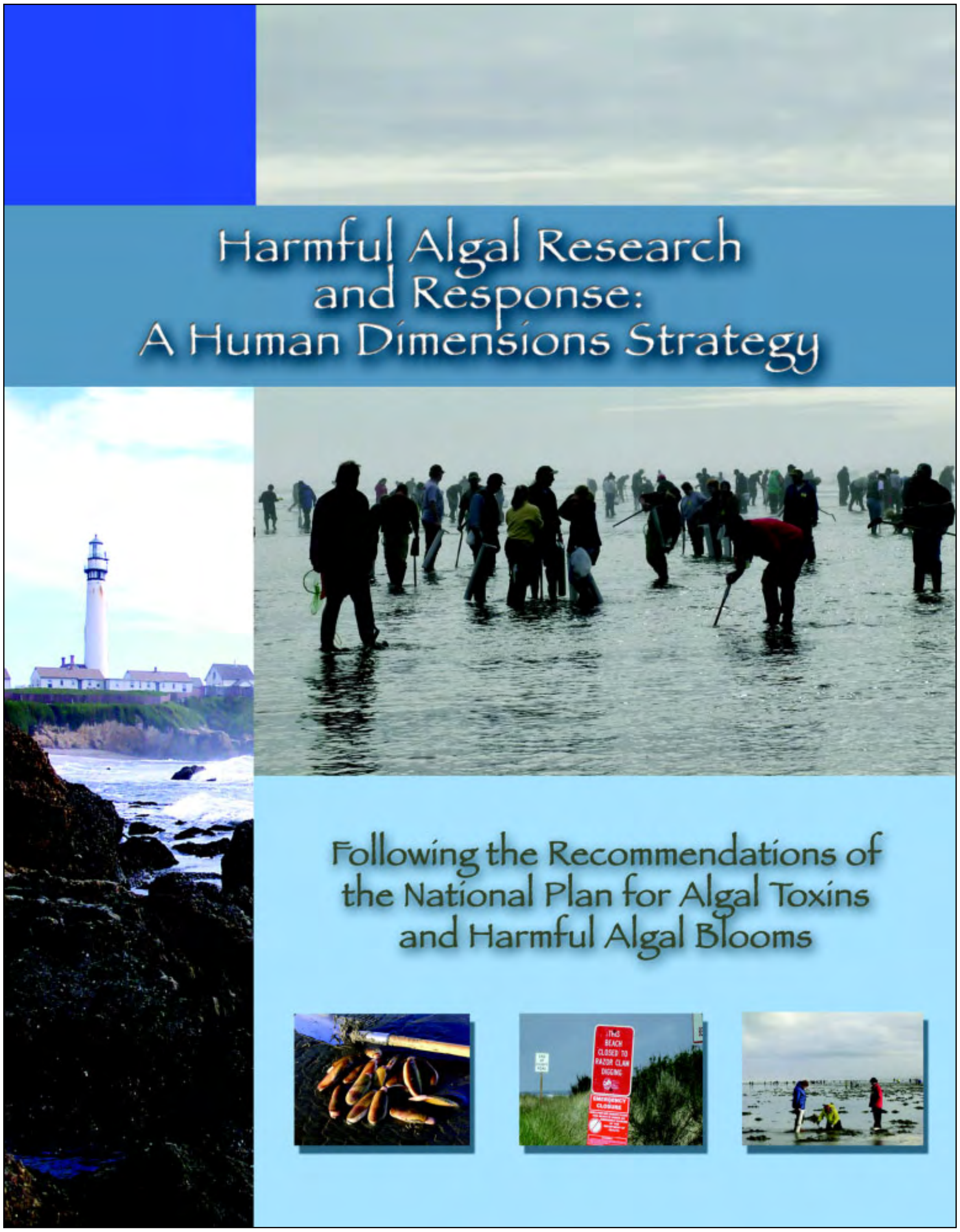


Image: Kevin McMahon, NOAA-CCMA

Available at http://www.coastalscience.noaa.gov/stressors/extremeevents/hab/HDstrategy.pdf

Chapter 9

Activity Flowcharts

Purpose *To present a methodology for developing flowcharts for responding to the various types of HAB events in Florida. To provide the user with sample flowcharts for modification and use at the local level.*

The following contains general information for developing flowcharts and provides both sample flowcharts of existing operations and case histories of event responses for guidance in developing response plans at the local level for HAB events.

Definition

A flowchart is a graphical representation of a process; it is designed to show the possible actions and outcomes involved. It should serve as a roadmap, ensuring that the process will be able to respond to every possible outcome.

Purpose of Flowcharts

Adapted from Flowchart Tutorial, EDraw Flowchart Software

Flowcharts are useful management tools when developing preparedness plans. During the initial planning, finalizing the flowchart process may take up to one month; following initial design, charts should be updated once a year or as necessary.

Flowcharts can help to
- determine whether the steps in a process are logical;
- uncover problems, gaps, bottlenecks, weak links, poorly defined steps, and possible miscommunications;
- define the boundaries of a process; and
- develop a common understanding about a process.

Benefits of Flowcharts
- They promote understanding of the process by explaining steps pictorially.
- They provide a tool for training employees.
- They identify problem areas and opportunities for improvement and/or ways to streamline activities.

Pre-flowchart Steps
- Identify the right people to develop the chart.
- Determine what you expect to get from the chart.
- Identify who will use it and how.
- Define the level of detail you want.
- Establish the boundaries of the process to be improved (limits or how far you want to go into the process).

Tips
- Observe the current process (start with the process as it is, then focus on how the process"should be").
- Draw the flowchart after you have written the process steps.

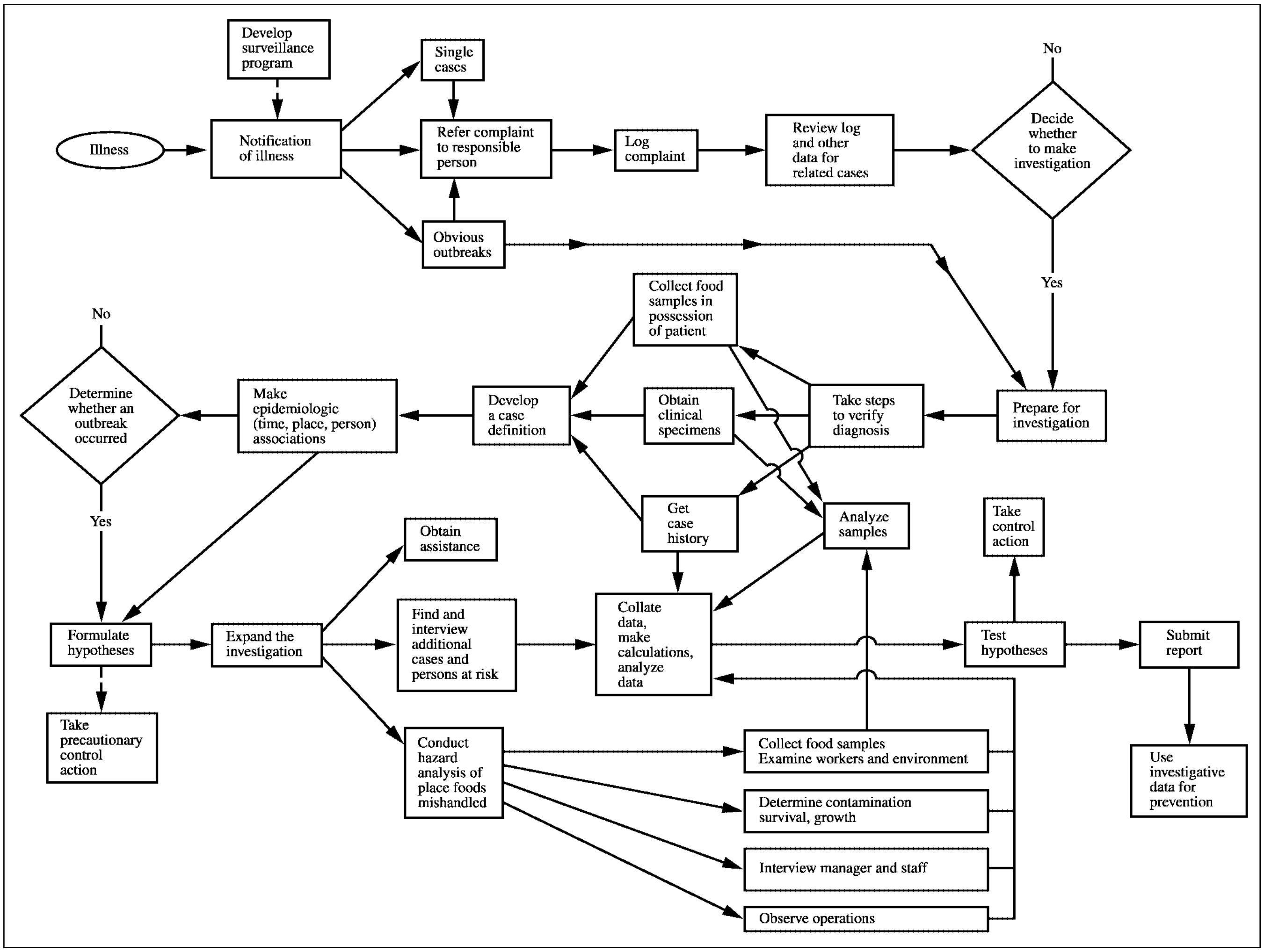


Figure 9.1 *Foodborne illness flowchart, Florida Department of Health investigation methods.*

Sample Flowcharts

The FDOH provides technical assistance to counties interested in developing locally appropriate flowcharts. Figures 9.1–9.6 are examples of existing operations and/or investigation methods that have been used in response to events. The FDOH investigates food-borne illness outbreaks by using the epidemiological operations flowchart shown in Figure 9.1. These include investigations of HAB-related illnesses from consumption of contaminated shellfish.

Flowchart for Blue-Green Algae or Cyanobacterial Bloom Response (Figure 9.2) Step Description

Adapted from Proceedings of Health Effects of Exposure to Cyanobacteria Toxins: State of the Science, August 13–14, 2002.

The FDOH, alongside other interagency response efforts, is working with CHDs to develop standard investigation methods for blue-green algae or cyanobacterial blooms. This includes investigation of blooms for preventive measures, such as beach closures, as well as for illness from exposure to contaminated water.

MONITORING

STEP 1

Visually monitor water treatment plant and/or water body for blue-green algae or cyanobacterial bloom development. Water bodies should be considered for monitoring based on susceptibility to algal blooms. Monitoring activities may be increased during peak seasons. If a bloom develops, proceed to Step 2. Some public water treatment plant facilities using surface water for source water have instituted a testing program based on their historical experience in dealing with cyanobacteria. At times, the testing is initiated in response to complaints of bad odor or taste; others use

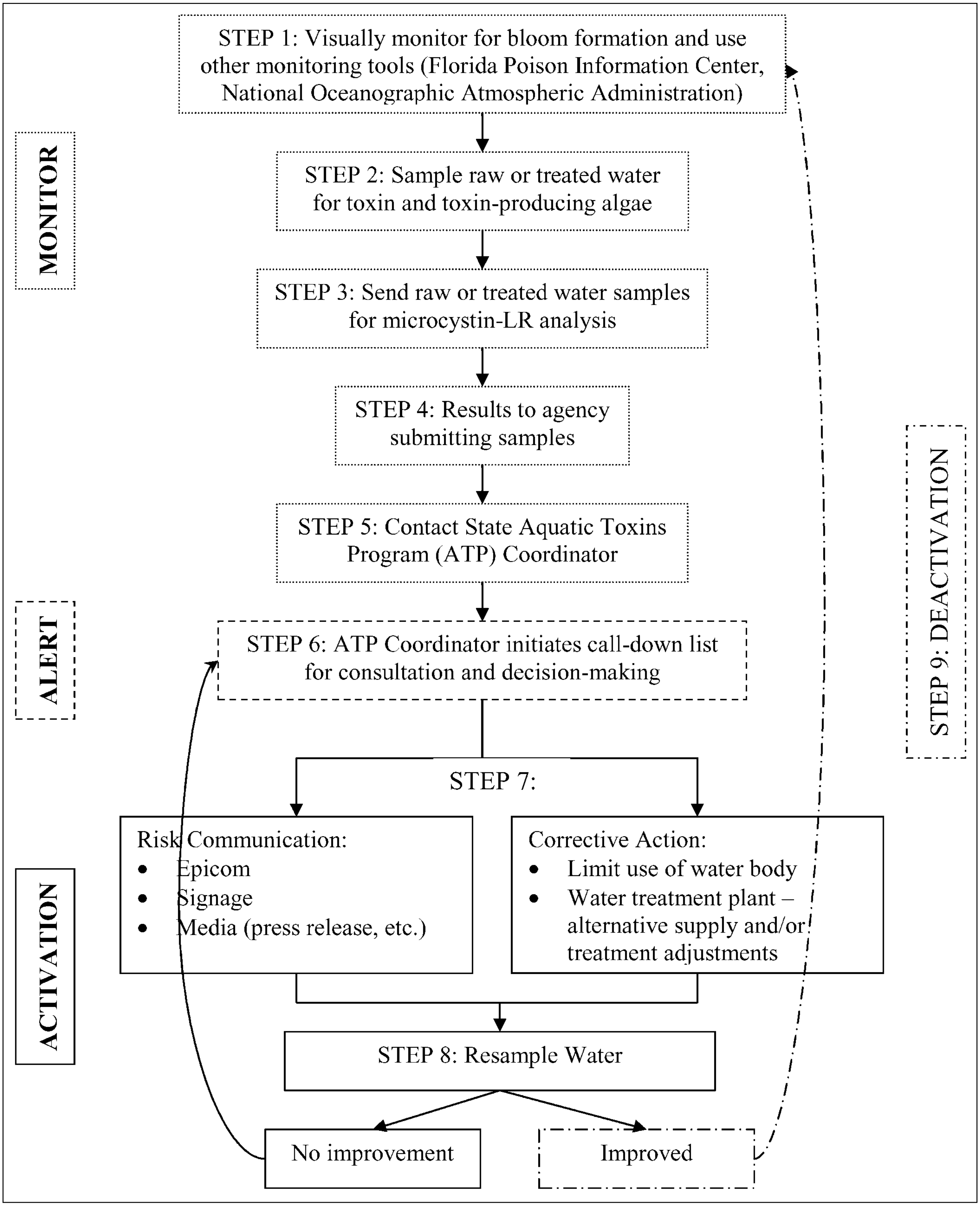


Figure 9.2 *Flowchart for blue-green algae or cyanobacterial bloom response for water treatment plants and water bodies in Florida (recreational and other).*

visual monitoring of the surface water body to identify a pending bloom and start analyses when scums start to form. There are no required or regulation-directed protocols in place at this time.

STEP 2
Sample raw or treated water for toxins and algal identification. For high-risk areas, this step may be conducted on a routine basis depending on the level of concern and the available resources in the county. A field test kit (currently in development by a number of research institutions) could be used as a screening tool to determine the presence or absence of toxins in the water supply. FDEP's standard operating procedures for sampling for cyanobacteria can be found at ftp://ftp.dep.state.fl.us/pub/labs/biology/hab/cyanobacteria_sop.pdf

STEP 3
Send raw or treated water samples for cyanotoxin analyses to a recognized analytical laboratory for confirmatory analysis. This step may be combined with Step 2.

STEP 4
Laboratory provides results of sample testing to local agency.

STEP 5
Local agency contacts FDOH's ATP Coordinator regardless of test results. The information will be used to assist with statewide surveillance efforts and contribute to a better understanding of HABs. Based on results, the local agency, together with the ATP, will make a decision on whether to proceed to the "alert" phase.

ALERT
STEP 6
ATP Coordinator initiates the call-down phone and/or email list for blue-green algae bloom response consultation. Members of the call-down phone and/or email list provide consultation and arrive at decision concerning the type of action to be taken. This is a valuable step to identify additional resources to support local efforts and determine roles and responsibilities of agencies involved.

ACTIVATION
STEP 7
Both risk communication and corrective action may be taken in Step 7. Decisions on which actions are to be taken will be determined through the consultation process.

STEP 8
Resampling of water should be conducted to determine whether response efforts to blue-green algae should remain activated. If no improvement in toxin or organism levels is observed, efforts should continue back at Step 6.

DEACTIVATION
STEP 9
If results of resampling demonstrate an improvement in the levels, the effort should be deactivated. Deactivation can include notification of improved conditions (*e.g.,* press release) or simply a return to Step 1.

Examples of Case-History Event Responses

At the 2006 coordinating meeting of the FHABTF Public Health Technical Panel, various examples of previous HAB case-history event responses were described. Figures 9.3 through 9.6 on the following pages summarize notification and response flow charts to these events as well as identify some of the challenges and difficulties that were encountered.

Notification groups could include the regional epidemiologist, FDACS, FDEP, FDOH–ATP, FWC, WMDs, health care workers, the media, and related industries (see Chapter 2, Agency Responsibility Matrices, and Appendix I for interagency contacts).

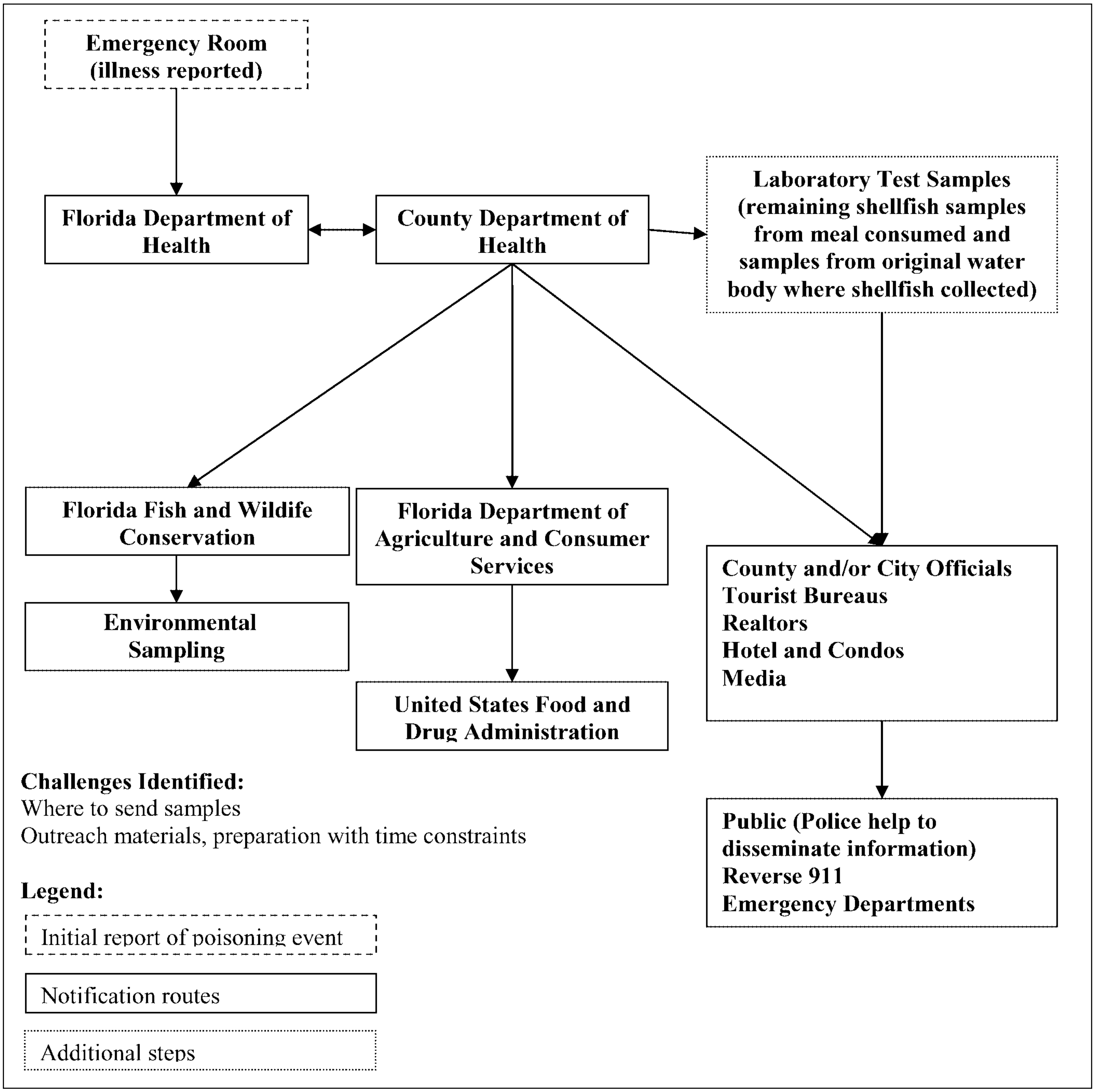
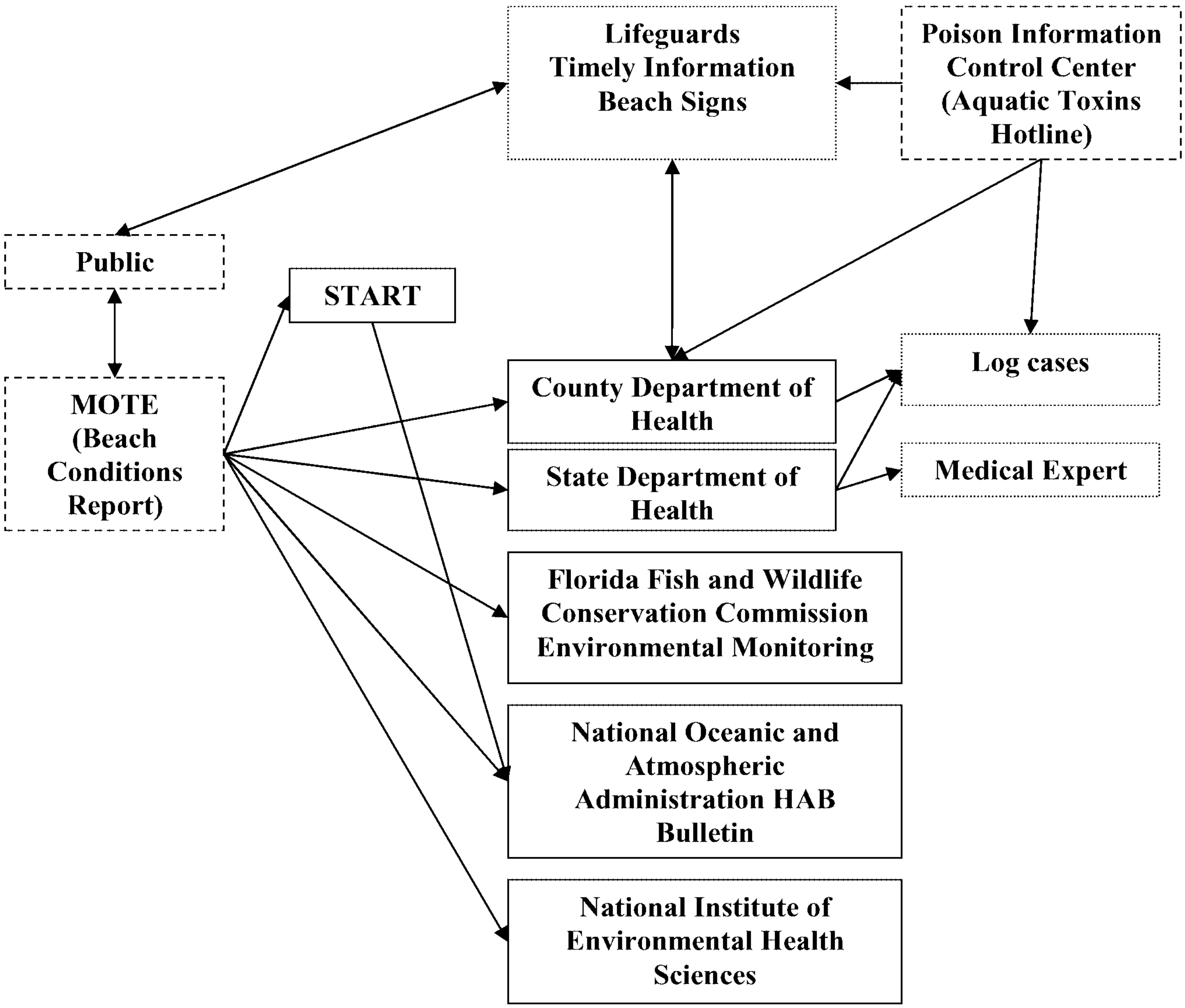


Figure 9.3 *Neurotoxic shellfish poisoning event in 2006.*



Challenges Identified:
Real-time dissemination of information to the public

Legend:

- Initial report of poisoning event
- Notification routes
- Additional steps

Figure 9.4 *Aerosol brevetoxin, red tide event.*

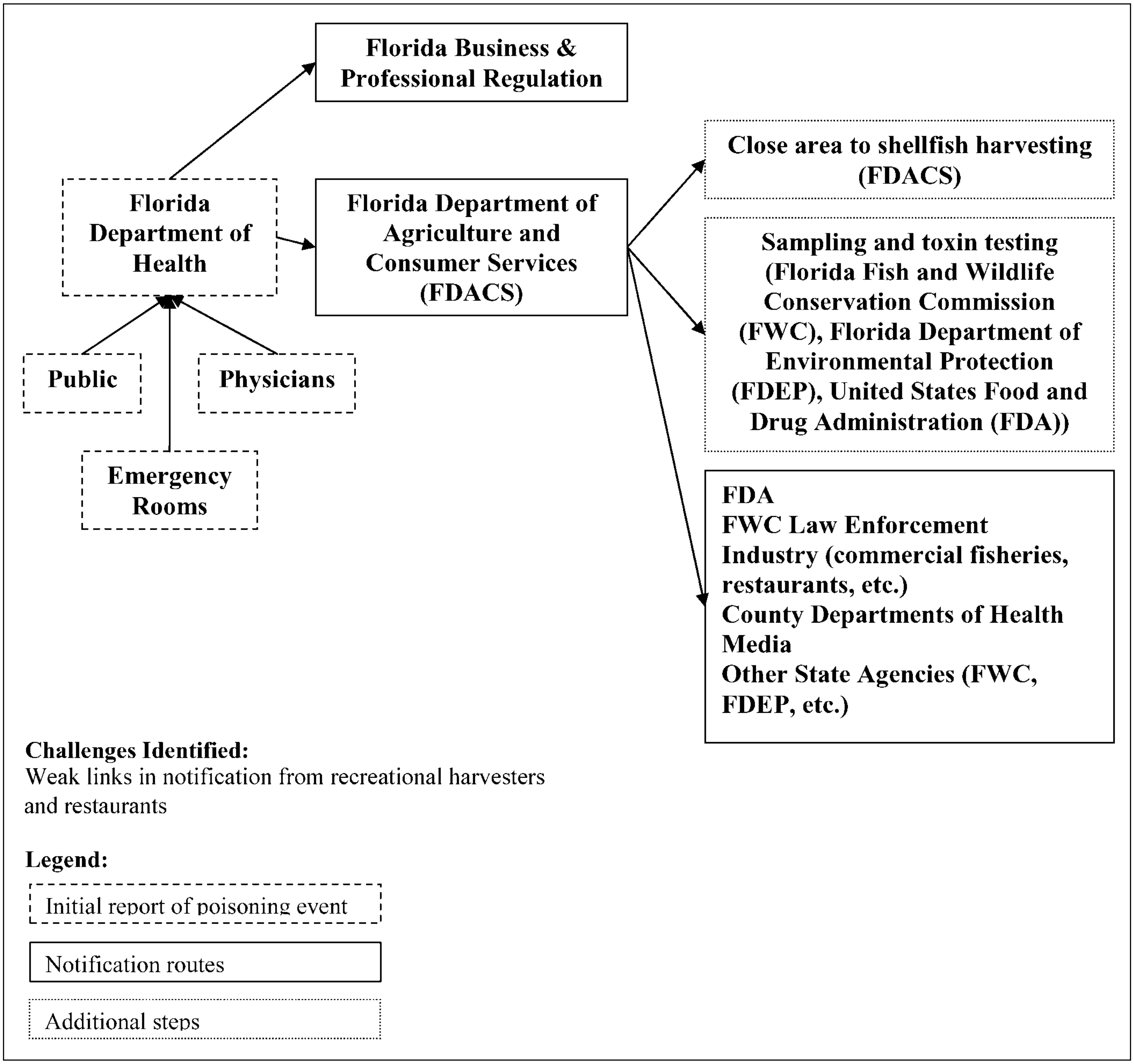


Figure 9.5 *Shellfish poisoning event (general).*

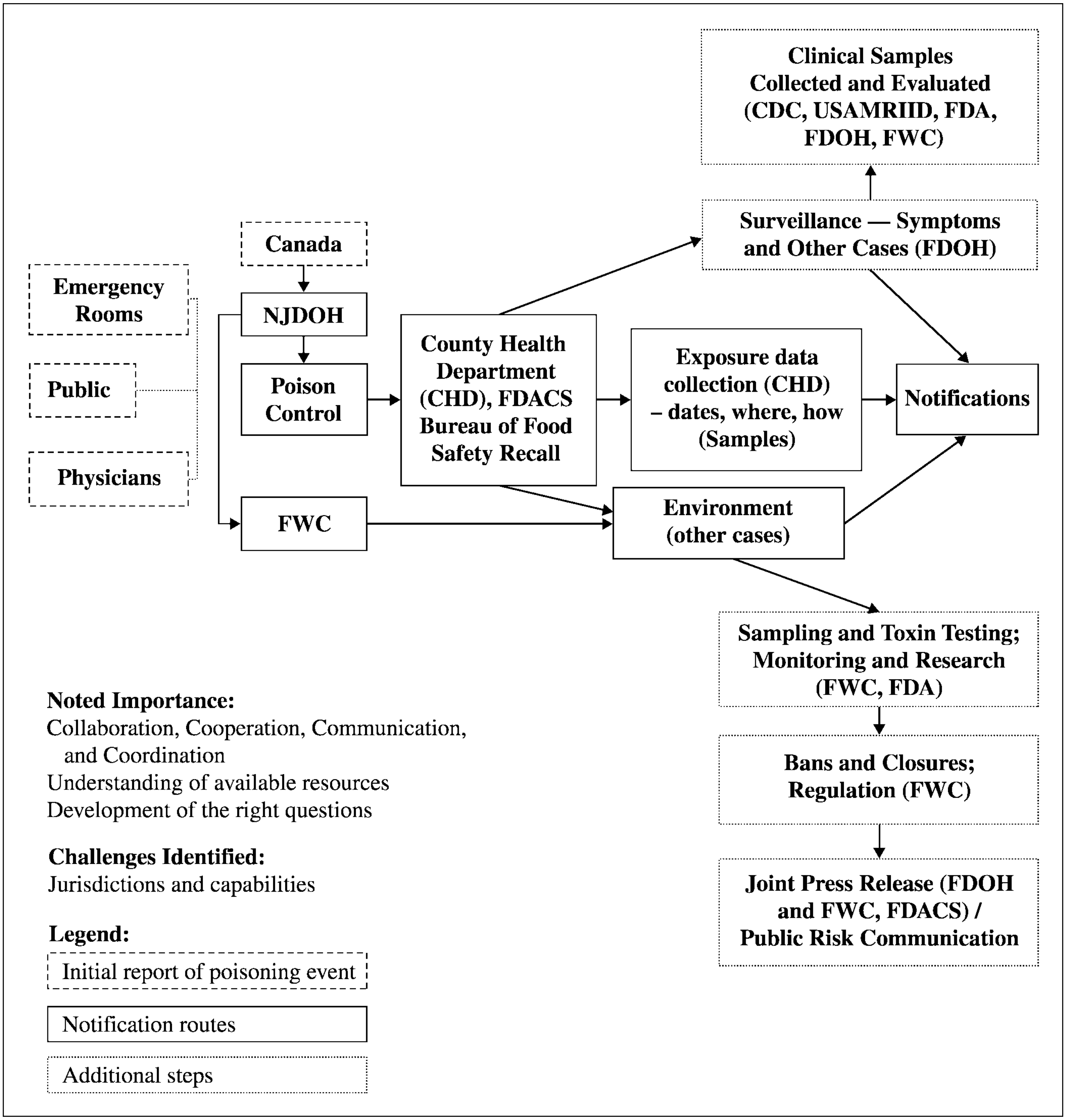


Figure 9.6 *Saxitoxin puffer fish poisoning event 2002.*

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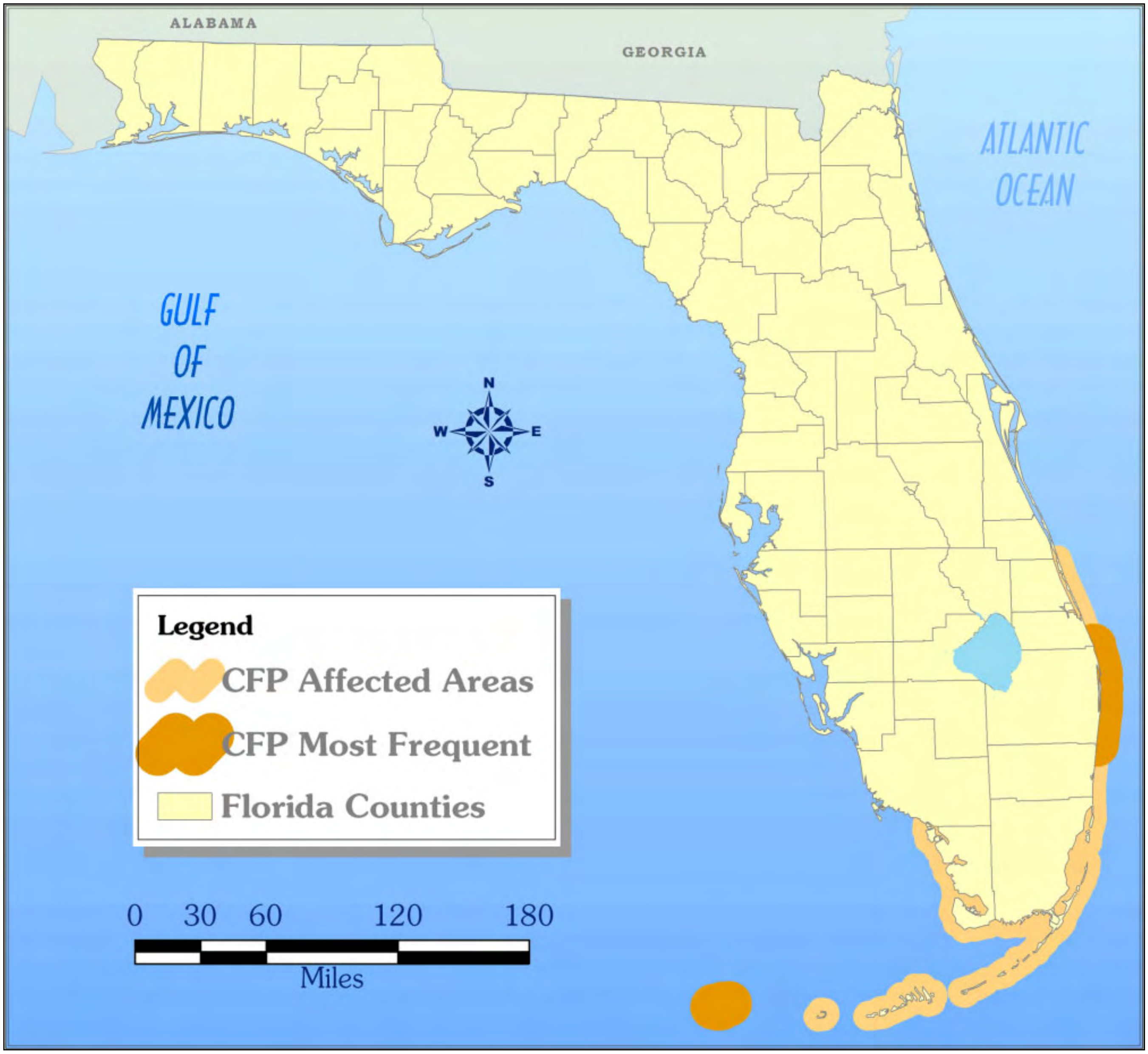
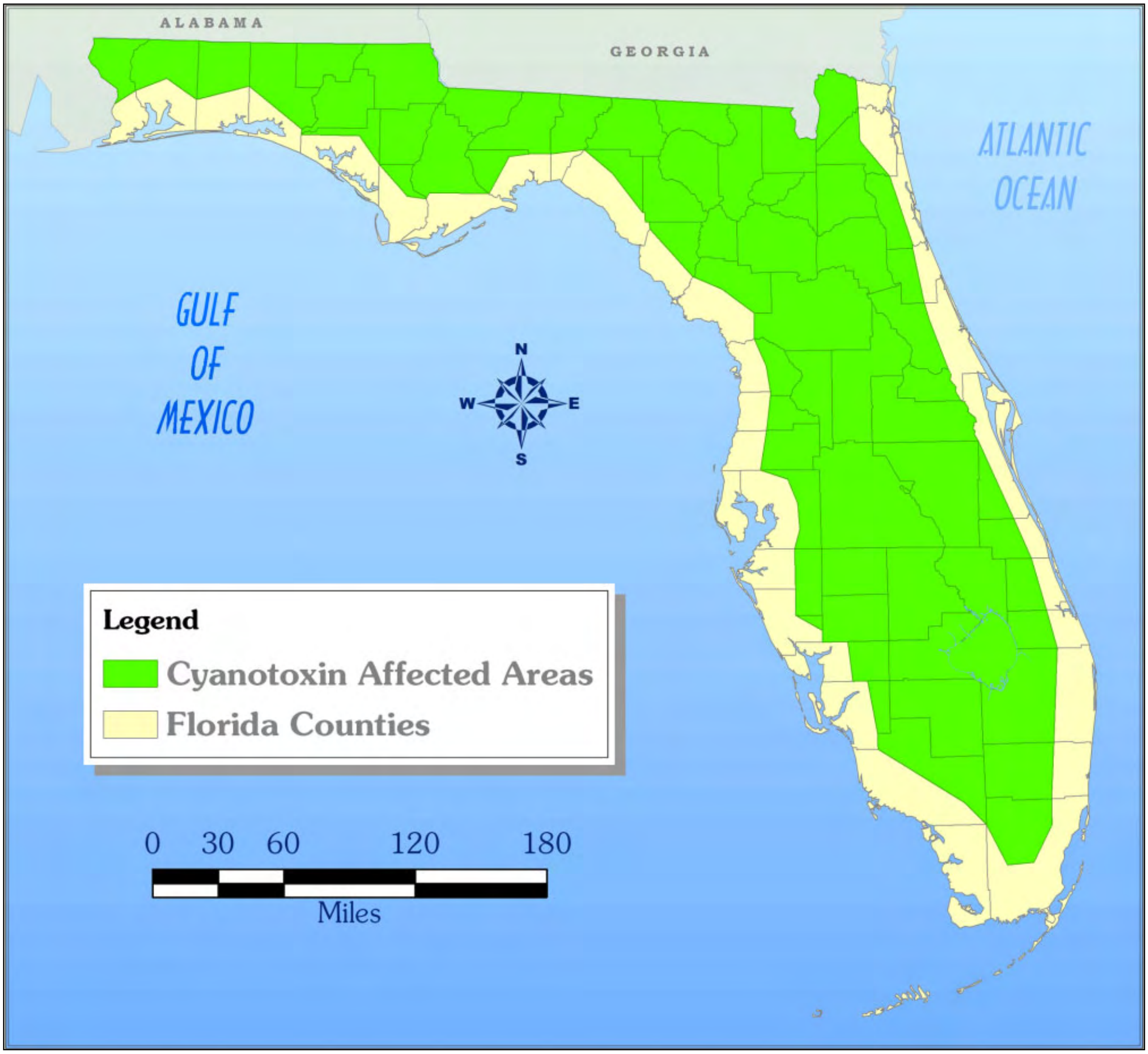
APPENDICES

Appendix A

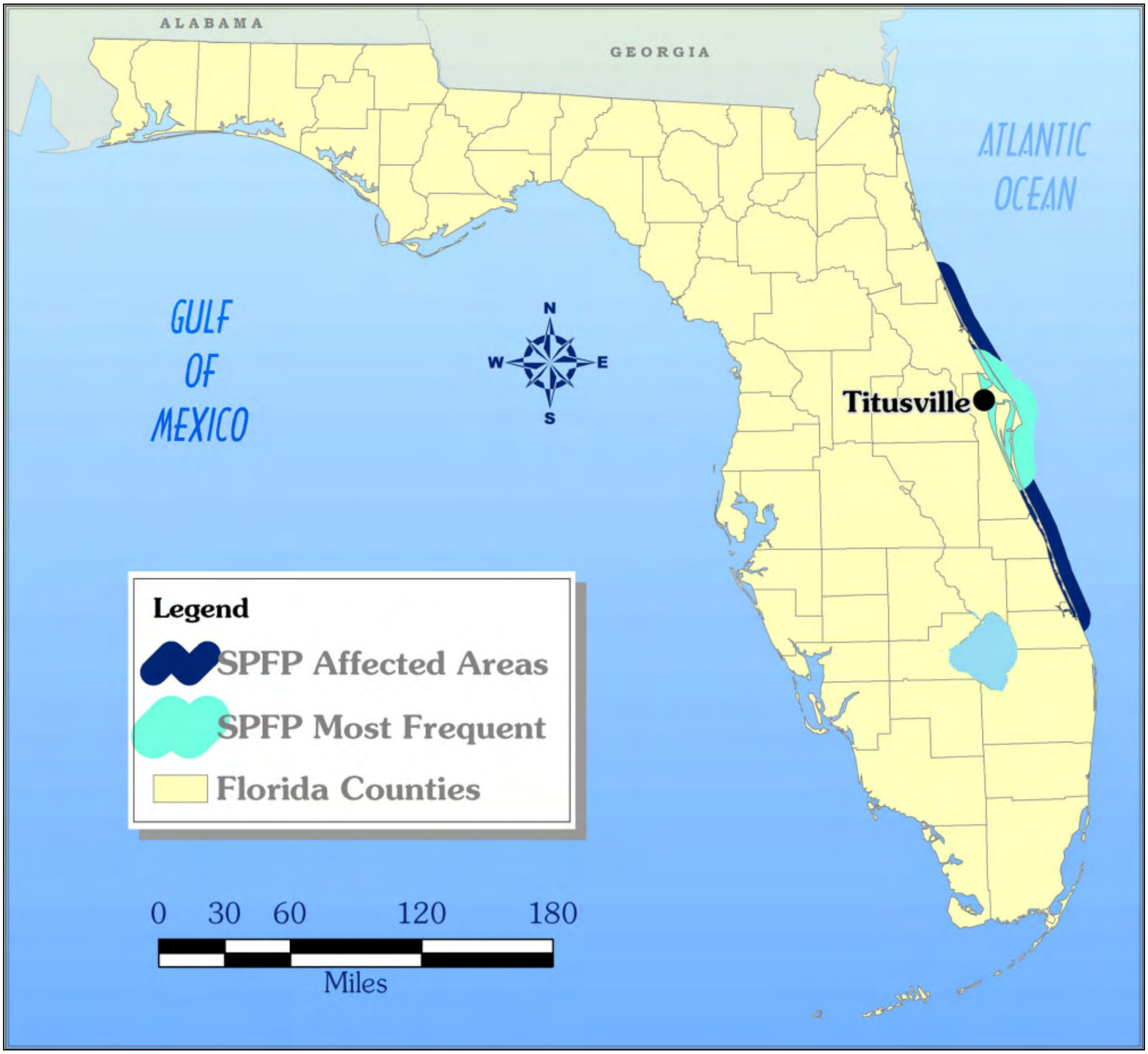
Maps of Specific Areas of Florida at High Risk for HAB Exposures (by County)

These four maps of potentially toxic HAB events have been included to help identify areas of Florida where specific HAB toxicity events most frequently occur. However, CHDs, FDOH, and PICs can get reports of human illness in a county where the seafood product was NOT harvested. For example, ciguateric fish have been caught in the Bahamas and taken back to the east coast of Florida. The reverse can also happen, such as in the case of New Jersey SPFP, in which fish harvested from the Indian River Lagoon were frozen and taken to New Jersey, where the human toxicosis occurred. When recording or investigating a case of seafood-related illness, it is critical to know where the product was harvested. (See Medical Fact Sheets Appendix B and Chapter 9 for additional details to aid in flowchart development and event response and case investigations).


ALABAMA
GEORGIA
ATLANTIC OCEAN
GULF OF MEXICO
N
W
E
S
Legend
CFP Affected Areas
CFP Most Frequent
Florida Counties
0 30 60 120 180
Miles


ALABAMA
GEORGIA
ATLANTIC
OCEAN
GULF
OF
MEXICO
N
W
E
S
Legend
Cyanotoxin Affected Areas
Florida Counties
0 30 60 120 180
Miles


ALABAMA
GEORGIA
ATLANTIC OCEAN
GULF OF MEXICO
N
W
E
S
Legend
NSP Affected Areas
NSP Most Frequent
Florida Counties
0 30 60 120 180
Miles


ALABAMA
GEORGIA
ATLANTIC OCEAN
GULF OF MEXICO
N
W
E
S
Titusville
Legend
SPFP Affected Areas
SPFP Most Frequent
Florida Counties
0 30 60 120 180
Miles

Appendix B

Medical Fact Sheets and Case Definitions

Medical Fact Sheet
Harmful Algae Bloom Series

Ciguatera Fish Poisoning

FLORIDA DEPARTMENT OF HEALTH

DIVISION OF
Environmental Health

Version 3 – 07/07/08

CAUSATIVE AGENT: Ciguatera fish poisoning (Ciguatera) is caused by the consumption of certain tropical and subtropical marine finfish that have accumulated toxins through their diet. These toxins, called ciguatoxins, originate from certain species of dinoflagellates (algae) that colonize coral reefs. The toxins accumulate in increasing concentration through the food chain starting from herbivorous fish ingesting the algae and ending with the top carnivore species. Fish most often implicated in ciguatera include the groupers, barracudas, snappers, jacks, mackerel, and triggerfish.

SIGNS/SYMPTOMS: Initial complaints typically include abdominal pain, nausea, vomiting, and diarrhea accompanied by progressive paresthesia, which first affects the areas of the mouth and later the extremities. Other symptoms include arthralgia, myalgia, blurred vision, muscular weakness, paradoxical temperature sensation (reversal of hot and cold sensation), metallic taste, tooth pain, headache, vertigo, arrhythmia, bradycardia or tachycardia, and hypotension. There is poor understanding of chronic exposures and long term health impacts.

ONSET/DURATION: Initial symptoms appear within 1–24 hours of consumption of ciguatoxic fish with the development of additional symptoms in 1–2 days. The illness often subsides within several days. However, in severe cases neurological symptoms may persist from weeks to months or, in rare cases, even years. Some recovered patients have experienced recurrence of neurological symptoms months or years after recovery. Such relapses are frequently associated with changes in dietary habits or with consumption of alcohol.

DIAGNOSIS: Diagnosis is based on a clinical evaluation of symptoms and diet history. Laboratory tests are not presently available for the diagnosis of ciguatera fish poisoning in humans. Mouse bioassay is the generally accepted technique for testing fish samples. An enzyme immunoassay (EIA) method for testing fish samples is under evaluation. Potentially implicated fish samples should be frozen until pick up by county health department personnel.

TREATMENT: No specific antitoxin is available. Gastrointestinal decontamination with activated charcoal may be of value if performed within 3–4 hours of ingestion. There is some evidence that intravenous administration of Mannitol within 24 hours of exposure may reduce neurological symptoms and sequela.

RISK GROUPS: All persons are susceptible to Ciguatera. However, young children, the elderly and those individuals with underlying neurologic disease may be at increased risk. Premature labor and spontaneous abortion have been reported, as well as effects on the fetus and newborn child through placental and breast milk transmission.

PREVENTATIVE MEASURES: Avoid eating barracuda and other large predatory reef fish. Contaminated shellfish are not detectable by taste or odor. It cannot be removed by cooking, freezing or other storage or preparation methods. Reoccurrence of symptoms have been observed in some recovered patients with subsequent ingestion of fish (regardless of type), alcohol, caffeine, and nuts so these items should be avoided for 3 to 6 months after recovery.

REPORTING REQUIREMENTS: Ciguatera cases **must** be reported to the local county health department pursuant to Section 381.0031 (1), Florida Statutes.

ADDITIONAL INFORMATION

Aquatic Toxins Hotline (24/7 medical information): **1-888-232-8635**
The Florida Department of Health's Aquatic Toxins Program at www.myfloridaeh.com

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Ciguatera Case Definition

Reporting code = 98809
Case report forms:

1. CDC 52.13 (9/89) Investigation of a Foodborne Illness Outbreak
2. (5/98) Record of Ciguatera Intoxication

Clinical description
Abdominal cramps, nausea, vomiting, diarrhea, numbness and paresthesia of lips and tongue, paresthesia of the extremities, metallic taste, arthralgia, myalgia, blurred vision and paradoxical temperature sensation. Associated with consumption of reef or bottom-dwelling fish such as barracuda and snapper

Case classification
Confirmed: A clinically compatible illness in a patient with a history of fish consumption in the 24 hours before onset of symptoms

Laboratory criteria for diagnosis

- Detection of ciguatoxin in implicated fish helpful, but not necessary for case confirmation

Comment
Even single sporadic cases should be reported on the CDC Investigation of a Foodborne Outbreak form and the Record of Ciguatera Intoxication. Testing for the toxin in implicated fishes is available from the FDA. Contact your regional foodborne illness investigator for information.

From
Surveillance Case Definitions for Select Reportable Diseases in Florida
Bureau of Epidemiology
Florida Department of Health
June 2003

Additional Information
Florida Department of Health: www.myfloridaeh.com under Food and Waterborne Surveillance Program; Aquatic Toxins Program

Medical Fact Sheet
Harmful Algae Bloom Series

Blue-Green Algae Toxin (Cyanotoxin) Illness

FLORIDA DEPARTMENT OF HEALTH

DIVISION OF
Environmental Health

Version 3 – 07/07/2008

CAUSATIVE AGENT: Blue-green algae toxin (cyanotoxin) illness results from exposure to the toxins associated with organisms known as cyanobacteria. Their complexity, diversity and number of species involved makes the assessment of health impacts an emerging research and medical issue. Species of blue-green algae that form HABs in fresh water include *Microcystis aeruginosa, Anabena circinalis, Anabena flos-aquae, Aphanizomenon flos-aquae, Cylindrospermopsis raciborskii, Lyngbya wollei* and *Oscillatoria.* Exposure can occur through ingestion of contaminated drinking water, inadvertent ingestion via recreational water activities, use of contaminated dietary supplements and possibly from inhalation of aerosols containing cyanotoxins and dermal contact with surface water. The cyanotoxins belong to diverse groups of chemical substances with specific toxic mechanisms including neurotoxins (anatoxin-a, anatoxin-a(s), saxitoxin, neosaxitoxin), hepatotoxins (microcystins, nodularins, cylindrospermopsin), tumor promoters (microcystins) and dermatotoxins (include aplysiatoxins and lyngbyatoxin, (also potent tumor promoters and protein kinase C activators) and lipopolysaccharides, also known as LPS (also gastroenteritis and possibly causing dermatitis).

SIGNS/SYMPTOMS: Skin contact has been reported to produce rash, hives, or skin blisters (especially on the lips and under swimsuits). Inhaling water droplets from irrigation or water-related recreational activities have been reported to cause runny eyes and nose, a sore throat, asthma-like symptoms, or allergic reactions. Ingestion can cause acute, severe gastroenteritis (including diarrhea, vomiting); liver toxicity (nausea, vomiting and acute liver failure); kidney toxicity, and neurologic effects such as salivation, muscle cramps, twitching, paralysis and cardiac or respiratory failure (these are the symptoms most often seen in dogs who have been exposed to anatoxin). There is poor understanding of the health effects from chronic exposures.

ONSET/DURATION: With exposure to neurotoxic cyanotoxins, symptoms can appear within minutes to few hours of exposure, but may take up to 36 hours to manifest themselves. Hepatotoxin symptoms can appear rapidly within hours, but may occur as late as several days following exposure to high amounts of cyanotoxins.

DIAGNOSIS: Diagnosis is based on a clinical evaluation of symptoms and exposure history. Environmental samples should include assessment by microscopic identification of cyanobacteria and analytical testing by HPLC/MS and ELISA. Increased serum levels of liver enzymes have been associated with hepatic injury after cyanotoxin ingestion. Clinical laboratory tests are not presently available for the diagnosis of cyanotoxin poisoning in humans. Research efforts are underway to assess the potential to detect certain cyanotoxins in blood.

TREATMENT: In general, the only treatment available for exposure to the blue green algal toxins is supportive medical treatment after complete removal from exposure. If the exposure was oral, administration of activated carbon to decrease gut absorption may be efficacious if given within hours of exposure. Artificial respiration with exposure to the neurotoxins (such as saxitoxin) should also be considered. Based on past outbreaks, monitoring of volume, electrolytes, liver and kidney function should all be considered in the case of acute gastroenteritis associated with some of the blue green algal toxins.

RISK GROUPS: All persons are susceptible to cyanobacteria. However, young children, the elderly and those individuals with underlying immunologic, neurologic, hepatic or kidney disease may be at increased risk. Effects on pregnancy and fetal health are unknown. Animals drinking raw water contaminated with toxin-producing cyanobacteria are especially prone to acute poisonings.

PREVENTATIVE MEASURES: Avoid contact with water or algae if visibly present (foam, scum, or mats of algae). Restrict swimming, boating and other activities in blooms. If exposed, rinse off with fresh water as soon as possible. Pets or livestock should not swim in or drink from areas where the water has. If pets (especially dogs) do swim in scummy water, rinse them off immediately—do not let them lick the algae (and toxins) off their fur. Algaecides may temporarily increase the amount of toxins in the water.

REPORTING REQUIREMENTS: None. At present, cyanotoxin illness is not a reportable disease in Florida. To improve their surveillance of this illness, the Florida Department of Health asks health care providers to report suspect cases to the Aquatic Toxin Hotline at 1-888-232-8635 or the Aquatic Toxins Program at the Florida Department of Health.

ADDITIONAL INFORMATION

Aquatic Toxins Hotline (24/7 medical information): **1-888-232-8635**

The Florida Department of Health's Aquatic Toxins Program at www.myfloridaeh.com

AQUATIC TOXINS PROGRAM

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Cyanotoxin Case Definitions

Developed and Proposed by North Carolina Department of Health
J. Newton MacCormack, MD, MPH
Occupational & Environmental Epidemiology Branch

Microcystin Poisoning

Possible case: Confirmed exposure (ingestion OR immersion) to water with confirmed bloom of cyanobacterial species capable of microcystin production **AND** clinical evidence of hepatic dysfunction (e.g., painful hepatomegaly; aminotransferase [AST/ALT] level at least 2 times normal) developing within 48 hours of exposure **AND** other causes of hepatic dysfunction have been excluded.
Probable case: Meets criteria for "possible case" **AND** there is laboratory documentation of microcystin toxin in water.
Confirmed case: Meets criteria for "probable case" **AND/OR** positive assay for microcystin toxin in clinical specimen (blood or tissue)

Cylindrospermopsin Poisoning

Possible case: Confirmed exposure (ingestion **OR** immersion) to water with confirmed bloom of cyanobacterial species capable of cylindrospermopsin production **AND** development of at least one of the following within 48 hours:

- clinical evidence of hepatic dysfunction (e.g., painful hepatomegaly; aminotransferase [AST/ALT] level at least 2 times normal)
- GI symptoms (e.g., nausea, vomiting, diarrhea, abdominal cramps)
- Proteinuria, hematuria, or other signs of acute renal damage.

Probable case: Meets criteria for "possible case" **AND** laboratory documentation of cylindrospermopsin toxin in water.
Confirmed case: Meets criteria for "probable case" **AND** positive assay for cylindrospermopsin toxin in clinical specimen (blood or tissue)

Additional Information

Florida Department of Health: www.myfloridaeh.com under Food and Waterborne Surveillance Program; Aquatic Toxins Program

Medical Fact Sheet
Harmful Algae Bloom Series

Neurotoxic Shellfish Poisoning (NSP)

FLORIDA DEPARTMENT OF HEALTH

DIVISION OF
Environmental Health

Version 3 – 07/07/2008

CAUSATIVE AGENT: Neurotoxic shellfish poisoning (NSP) is caused by the consumption of molluscan shellfish (e.g., clams, oysters, coquinas, mussels and other filter feeders) contaminated with brevetoxins, which are produced by a marine dinoflagellate called *Karenia brevis. K. brevis* is principally distributed throughout the Gulf of Mexico and occasionally along the mid- and south-Atlantic Coast. Commonly referred to as "Florida red tides," blooms of *K. brevis* most often occur during late summer and fall but can be present any time of the year.

SIGNS/SYMPTOMS: Initial complaints typically include abdominal pain, nausea, vomiting, and diarrhea accompanied by progressive paresthesia, which first affects the areas of the mouth and later the extremities. Other common symptoms include ataxia, myalgia, headache, and vertigo. Paradoxical temperature sensation (reversal of hot and cold sensations), as seen in ciguatera fish poisoning, has also been reported in NSP. In more severe cases of NSP, dilation of the pupils and bradycardia may also be observed. There is poor understanding of chronic exposures and long term health impacts

ONSET/DURATION: Onset of symptoms occurs within minutes to hours, definitely within 24 hours, of consuming brevetoxin-contaminated shellfish. Duration of the illness is generally short, lasting from a few hours to several days. Urine analyses by specialty laboratories (such as Fish and Wildlife Research Institute) can confirm exposure with positive tests for brevetoxin. Samples should be preserved at –20°C and shipped on dry ice with overnight delivery. Arrangements must be made with laboratory before submitting samples for analyses.

DIAGNOSIS: Diagnosis is generally based on a clinical evaluation of symptoms and recent food history. The use of an ELISA test for detecting brevetoxin in urine is experimental at this time. Mouse bioassay is the generally accepted technique for testing shellfish, however brevetoxin ELISA and HPLC may also be helpful.

TREATMENT: No specific antitoxin is available. In general the illness is self-limiting and therapy is supportive and symptom-driven.

RISK GROUPS: All persons are susceptible to NSP. However, young children, the elderly and those individuals with underlying neurologic disease may be at increased risk. Effects on pregnancy and fetal health are unknown.

PREVENTATIVE MEASURES: Contaminated shellfish are not detectable by taste or odor. It cannot be removed by cooking, freezing or other storage or preparation methods. The Florida Department of Agriculture and Consumer Services closes shellfish harvesting areas when *K. brevis* cell counts exceed 5,000 cells per liter. In recent years most NSP cases have been the result of illegal harvesting of shellfish from closed areas. See www.floridaaquaculture.com/seas/seas_statusmap.htm for shellfish harvesting area status.

REPORTING REQUIREMENTS: NSP cases must be immediately reported to the local county health department pursuant to Section 381.0031 (1), Florida Statutes.

ADDITIONAL INFORMATION

Aquatic Toxins Hotline (24/7 medical information): **1-888-232-8635**

Florida Department of Health's Aquatic Toxins Program at www.myfloridaeh.com

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Neurotoxic Shellfish Poisoning Case Definition

Reporting code = 98800
Case report form: CDC 52.13 (9/89)
Investigation of Foodborne Illness

Clinical case definition
Onset is within a few minutes to a few hours after consumption of epidemiologically implicated shellfish. Symptoms include tingling and numbness of lips, mouth, fingers, and toes; muscular aches; dizziness, reversal of hot and cold sensations; pupil dilation; and usually accompanied by diarrhea, vomiting and ataxia. Illness is self-limited and milder than paralytic shellfish poisoning; paralysis has not been documented. Duration is from a few minutes to a few hours or a few days at most.

Laboratory criteria for diagnosis
- Detection of toxin in epidemiologically implicated shellfish

Case classification
Confirmed: Clinically compatible illness that is associated with consumption of shellfish from areas where other toxic shellfish have been found.

From
Surveillance Case Definitions for Select Reportable Diseases in Florida
Bureau of Epidemiology
Florida Department of Health
June 2003

Additional Information
Florida Department of Health: www.myfloridaeh.com under Food and Waterborne Surveillance Program; Aquatic Toxins Program

Illness Fact Sheet
Harmful Algae Bloom Series

Saxitoxin Puffer Fish Poisoning

FLORIDA DEPARTMENT OF HEALTH

DIVISION OF
Environmental Health

Version 3 – 07/07/2008

CAUSATIVE AGENT: Saxitoxins are a family of water-soluble neurotoxins that are produced by several species of marine algae known as dinoflagellates (*Pyrodinium, Gymnodinium* and *Alexandrium*). In most parts of the United States, saxitoxin poisoning is generally associated with the consumption of shellfish (known as paralytic shellfish poisoning or PSP). However in Florida saxitoxin poisoning has been associated with the consumption of puffer fish (includng the fillet and tail portion) contaminated with saxitoxin and harvested from the Indian River Lagoon.

SIGNS/SYMPTOMS: Symptoms of saxitoxin poisoning include: circumoral paresthesia, numbness or tingling of the face, arms, and legs, motor uncoordination, respiratory distress, headache, dizziness, weakness, nausea and vomiting. In severe cases, acute muscle paralysis and respiratory failure can occur rapidly. There is poor understanding of chronic exposures and long term health impacts.

ONSET/DURATION: The onset of symptoms is rapid, generally occurring within 15 minutes to 10 hours following consumption. In severe cases, death from respiratory failure can occur in 2 to 25 hours. Patients with appropriate supportive treatment reportedly recover fully although this has not been well researched.

DIAGNOSIS: Diagnosis is generally based on a clinical evaluation of symptoms and recent food history. (Sometimes, it's misdiagnosed as fugu poisoing.) Mouse bioassay is the generally accepted technique for testing food extract, but it cannot distinguish between tetrodotoxin and saxitoxin. Radioimmunoassay and indirect enzyme-linked immunoabsorbent assay (ELISA) have been developed for saxitoxin, but not all PSP toxins. HPLC analysis method for all the PSP toxins has been developed with good correlation with mouse bioassay in terms of quantification.

TREATMENT: No specific antitoxin is available. Supportive measures are the basis of treatment, especially ventilatory support in severe cases.

RISK GROUPS: All persons are susceptible to saxitoxin poisoning, but children and the elderly may be at greater risk. Effects on pregnancy and fetal health is unknown.

PREVENTATIVE MEASURES: The shellfish and fish reportedly taste delicious. Saxitoxin cannot be removed by cleaning or cooking affected fish or shellfish. It cannot be removed by freezing or other storage or preparation methods. The Florida Fish and Wildlife Conservation Commission has banned harvesting puffer fish from the waters of Volusia, Brevard, Indian River, St. Lucie, and Martin Counties.

REPORTING REQUIREMENTS: Saxitoxin Poisoning cases must be reported to the local county health department pursuant to Section 381.0031 (1), Florida Statutes.

ADDITIONAL INFORMATION

Aquatic Toxins Hotline (24/7 medical information): **1-888-232-8635**
The Florida Department of Health's Aquatic Toxins Program at www.myfloridaeh.com

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Saxitoxin Poisoning Case Definition (including Paralytic Shellfish and Puffer Fish)

Reporting code = 98840
Case report form: NA

Clinical description
A person with circumoral paresthesia, numbness or tingling of the face, arms, and legs, motor uncoordination, respiratory distress, headache, dizziness, weakness, nausea, and vomiting, 15 minutes to 10 hours following the consumption of puffer fish caught off the Florida coast or from the consumption of molluscan shellfish (from any source). In severe cases muscle paralysis and respiratory failure occur, with death occurring in 2 to 25 hours.

Case classification
Confirmed: a clinically compatible case that is laboratory confirmed
Suspect: a clinically compatible case that is not laboratory confirmed and has a demonstrated epidemiologic link

Laboratory criteria for diagnosis
- Toxin detection in urine or epidemiology linked food specimen

From
Surveillance Case Definitions for Select Reportable Diseases in Florida
Bureau of Epidemiology
Florida Department of Health
June 2003

Additional Information
Florida Department of Health: www.myfloridaeh.com under Food and Waterborne Surveillance Program; Aquatic Toxins Program

Medical Fact Sheet
Harmful Algae Bloom Series

Brevetoxin-associated Respiratory Syndrome (aka Red Tide Cough)

FLORIDA DEPARTMENT OF HEALTH

DIVISION OF
Environmental Health

Version 3 – 07/07/2008

CAUSATIVE AGENT: Brevetoxin-associated Respiratory Syndrome is caused by the inhalation of aerosolized brevetoxins, which are produced by the marine algae known as dinoflagellates called *Karenia brevis.* Commonly referred to as "Florida red tides," blooms of *K. brevis* most often occur during late summer and fall, but can be present any time of the year in marine waters. *K. brevis* is principally distributed throughout the Gulf of Mexico and occasionally along the mid- and south-Atlantic Coast.

SIGNS/SYMPTOMS: Acute symptoms include conjunctival irritation, catarrhal exudates, rhinorrhea, nonproductive cough, and bronchoconstriction. Wheezing, shortness of breath, and chest tightness are also common, especially among persons with underlying respiratory disease such as asthma. Other symptoms, such as dizziness, itchiness, and tinnitus, have also been reported. There is poor understanding of chronic exposures and long term health impacts.

ONSET/DURATION: Onset of symptoms is rapid, typically within minutes of exposure. In healthy individuals symptoms reportedly subside quickly once exposure to aerosolized brevetoxins ceases. However, symptoms may linger for hours or even days after prolonged exposure or in individuals with underlying respiratory disease.

DIAGNOSIS: Diagnosis is generally based on a clinical evaluation of symptoms and exposure.

TREATMENT: No specific antitoxin is available. In experimental animals, treatment with bronchodilators (i.e., Albuterol) reversed the effects of inhaled brevetoxins. Inhaled steroids, antihistamines, bronchodilators, and anticholinergics (i.e., Benedryl, Cromolyn, Albuterol, and Atropine) decreased the effects when taken prior to exposure.

RISK GROUPS: All persons are susceptible. Persons with underlying respiratory disease may be at increased risk of asthma exacerbations, sinusitis, bronchitis, and pneumonia. Effects on pregnancy and fetal health are unknown.

PREVENTATIVE MEASURES: Research suggests the greatest effects coincide with onshore winds in conjunction with high organism and toxin levels in near-shore waters such as on beaches and boats. Nuisance (dust) masks may decrease exposure to aerosolized brevetoxins. Anecdotal evidence suggests that once the person is removed from the exposure environment and goes into air conditioning, symptoms may be alleviated. Individuals with underlying respiratory disease should take precautions to avoid or minimize exposure.

REPORTING REQUIREMENTS: At present, Brevetoxin-associated Respiratory Syndrome is not a reportable disease in Florida. To improve their surveillance of this illness, the Florida Department of Health asks health care providers to report suspect cases to the Aquatic Toxin Hotline at 1-888-232-8635 or the Aquatic Toxins Program at the Florida Department of Health.

ADDITIONAL INFORMATION

Aquatic Toxins Hotline (24/7 medical information): **1-888-232-8635**

Florida Department of Health Aquatic Toxin Program at www.myfloridaeh.com

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Appendix C

Human Health Threats from Harmful Algal Bloom Species

A quick reference guide to the Medical Fact Sheets.
See Appendix B for complete information.

Quick Reference Guide—Part A

Illness	Implicated Species	Toxin	Factors Affecting Degree of Toxicity*	Diagnosis
Amnesic Shellfish Poisoning (ASP)	*Pseudo-nitzschia* species (diatom) *e.g., P. multiseries* and *P. calliantha*	domoic acid and derivatives	amount of toxin ingested, rate of toxin elimination, biotransformation of toxins, health of victim	history of recent consumption of seafood, symptoms, analyses of food **Note:** not reported from Florida
Ciguatera Fish Poisoning (CFP)	*Gambierdiscus toxicus* and other *Gambierdiscus* spp.	ciguatoxin, maitotoxin	amount of toxin ingested, rate of toxin elimination, repeated exposure, health of victim	history of recent consumption of seafood, symptoms, analyses of food **Note:** neurological symptoms may recur for months or years
Cyanotoxins (blue-green algae)	multiple species, *e.g., Microcystis aeruginosa, Anabaena circinalis, Lyngbya wollei, Cylindrospermopsis* spp.	multiple	amount of toxin exposed to, health of victim	topical exposure to scummy waters, ingestion of contaminated water, or unintentional ingestion of raw water
Diarrheic Shellfish Poisoning (DSP)	*Dinophysis* species, *e.g., D.* cf *ovum; Prorocentrum lima*	okadaic acid, dinophysis toxin	amount of toxin ingested, rate of toxin elimination, health of victim	history of recent consumption of seafood, symptoms, analyses of food. **Note:** not reported from Florida
Neurotoxic Shellfish Poisoning (NSP)	*Karenia brevis* (formerly *Gymnodinium breve*)	brevetoxin and derivatives	amount of toxin ingested, rate of toxin elimination, health of victim, bio-transformation of toxin	history of recent consumption of seafood, symptoms, analyses of food; detection of metabolites via radio-immunoassay (RIA) of urine

(Part A continued on page 108)

*** NOTE:** Symptoms are more severe in children, the elderly, and those with impaired immune systems.
Adapted from multiple references; see Chapter 1, Overview of Harmful Algal Blooms Significant to Public Health.

Quick Reference Guide—Part B

Illness	Symptoms: Acute	Symptoms: Subsequent, Other, or Severe Case	Route of Exposure	Treatment
ASP	**(within 24 hrs)** vomiting, abdominal cramps, diarrhea, nausea, headache	disorientation, memory loss, seizures, coma; has been fatal in humans **Note:** memory loss can last for more than one year	seafood	symptomatic (gut emptying, charcoal decontamination, ventilators); atropine for bradycardia; dopamine or calcium gluconate for shock; amitriptyline successful in relieving chronic symptoms (fatigue, paraesthesias)
CFP	**(1–12 hrs after ingestion)** sensory disturbances, *e.g,* paraesthesias, arthralgia, myalgia, asthenia, chills, headache, nausea; perspiration, tearing, giddiness; pruritus; abdominal pain; vomiting, diarrhea	**(12–18 hrs after ingestion)** headaches, itchy skin, hot–cold reversal, abnormal tingling or burning of the skin or extremities, muscle and joint pain, convulsions, muscular paralysis, audiovisual hallucinations, vertigo, irregular pulse rate, decreased blood pressure, sensitivity to certain foods (*e.g.,* caffeine and nuts) with reoccurrence of some symptoms for up to 3–6 mos. **Note:** toxins interact with opiates and barbiturates, causing hypertension	generally associated with reef predators including barracuda, grouper, snapper, amberjack, kingfish, mahi mahi; can also affect some herbivores such as parrotfish	symptomatic, no permanent cure, mannitol if diagnosed within 24 hours
Cyanotoxins (blue-green algae)	skin rashes or irritations, gastrointestinal distress, eye irritation, asthma	this is an emerging issue, and the symptomatology has not been fully described for U.S. exposures to multiple cyanobacteria species	aerosol, water, food	symptomatic
DSP	**(within 30 min–12 hrs, average incubation is 4 hrs)** nausea, vomiting, diarrhea, abdominal pains, chills		seafood	symptomatic, **(within 3 days)** complete clinical recovery, even in severe cases
NSP	**(within hours)** hot and/or cold sensation reversals, tingling, pins and needles feeling in extremities, nausea, diarrhea, vertigo, pupil dilation	**(within 2–3 days)** symptoms disappear	chione clams, other clams, oysters, gastropods, *e.g.,* whelk	symptomatic; no known antidote; full recovery in humans usually within several days

(Part B continued on page 109)

* **NOTE:** Symptoms are more severe in children, the elderly, and those with impaired immune systems.
Adapted from multiple references; see Chapter 1, Overview of Harmful Algal Blooms Significant to Public Health.

Quick Reference Guide—Part A *(continued)*

Illness	Implicated Species	Toxin	Factors Affecting Degree of Toxicity*	Diagnosis
Brevetoxin-Associated Respiratory Syndrome (Red Tide Cough)	*Karenia brevis* (formerly *Gymnodinium breve*)	brevetoxin and derivatives	amount of toxin inhaled, rate of toxin elimination, health of victim, biotransformation of toxin	history of recent beach activity in vicinity of marine waters with known red tide bloom
Paralytic Shellfish Poisoning (PSP)	*Pyrodinium bahamense*	saxitoxin and derivatives	amount of toxin ingested, rate of toxin elimination, health of victim, biotransformation of toxin	history of recent consumption of seafood, symptoms, toxin detection in urine, analyses of food **Note:** similar symptoms can come from exposure to certain pesticides (*e.g.*, carbamates, organo-phosphates); not reported from Florida
Saxitoxin Puffer Fish Poisoning (SPFP)	*Pyrodinium bahamense*	saxitoxin and derivatives	amount of toxin ingested, rate of toxin elimination, health of victim	history of recent consumption of seafood, symptoms, toxin detection in urine, analyses of food **Note:** similar symptoms from exposure to certain pesticides (*e.g.*, carbamates, organo-phosphates)

* **NOTE:** Symptoms are more severe in children, the elderly, and those with impaired immune systems.
Adapted from multiple references; see Chapter 1, Overview of Harmful Algal Blooms Significant to Public Health.

Quick Reference Guide—Part B *(continued)*

Illness	Symptoms: Acute	Symptoms: Subsequent, Other, or Severe Case	Route of Exposure	Treatment
BARS (Red Tide Cough)	**(within minutes)** wheezing, shortness of breath, chest tightness, dizziness, itchiness, and tinnitus	**(within hours–days)** symptoms disappear **Note:** effects from chronic exposures and long-term health impacts, particularly in individuals with asthma or underlying respiratory disease, are unknown	aerosol	respiratory irritation usually ceases when individual leaves area
PSP	**(30 min–3.5 hrs)** abnormal tingling or burning of the skin or extremities, loss of muscular coordination, giddiness, staggering, drowsiness, dry throat and skin, loss of speech or speech comprehension, rash, fever, nausea, vomiting, diarrhea.	**(24 hrs)** severe cases may lead to respiratory paralysis causing death **Note:** symptoms usually disappear within a few days with no lasting effects	seafood	symptomatic; no known antidote
SPFP	**(30 min–3.5 hrs)** abnormal tingling or burning of the skin or extremities, loss of muscular coordination, giddiness, staggering, drowsiness, dry throat and skin, loss of speech or speech comprehension, fever, nausea, vomiting	**(24 hrs)** severe cases may lead to respiratory paralysis causing death **Note:** symptoms usually disappear within a few days with no lasting effects	pufferfish (primarily southern puffer fish)	symptomatic

*** NOTE:** Symptoms are more severe in children, the elderly, and those with impaired immune systems.
Adapted from multiple references; see Chapter 1, Overview of Harmful Algal Blooms Significant to Public Health.

Appendix D

Known or Potentially Toxic or Harmful Algal Species in Florida

Impact	Species	Habitat	Distribution	Comments
Anatoxin-a (acute toxicity [LD_{50} i.p. mouse] is 250 µg/kg)				
Cyanobacteria				
Potential for wildlife and fish kills, loss of habitat, human health concerns	*Anabaena circinalis*	Freshwater, estuarine, planktonic	FL	Blooms common throughout FL; Lake Istokpoga, September 1988—signs of poisoning in lab mice indicated a neurotoxin; implicated in fish kills in St. Johns River 1999
Unknown	*Anabaena spiroides*	Freshwater, planktonic	FL	
Unknown	*Microcystis* sp.	Freshwater, estuarine, planktonic	FL	*Microcystis* blooms common throughout FL; Lake Okeechobee, August 1987—signs of poisoning in lab mice indicated a hepatotoxin
Azaspiracid (acute toxicity [minimum LD_{50} i.p. mouse] is 140–200 µg/kg)				
Dinoflagellates				
Potential for Azaspiracid shellfish poisoning (AZP)	*Protoperidinium crassipes*	Coastal planktonic	Gulf-wide	Recently caused human shellfish poisoning incidents in Europe; no toxic events reported in FL
Brevetoxins (acute toxicity [LD_{50} i.p. mouse] is 200 µg/kg)				
Dinoflagellates				
Neurotoxic shellfish poisoning (NSP), aquatic animal mortalities, respiratory irritation in humans	*Karenia brevis* (formerly *Gymnodinium brevis*)	Oceanic, coastal, or estuarine planktonic	Gulf-wide, Atlantic coast FL	Documented ~60 times in the past 150 years; persistent in FL coastal waters over the past 50 years; from 1994–1996 ranged from Dry Tortugas to Pensacola and occurred with *A. monilatum* in northwest FL and *K. mikimotoi* in southwest FL; NSP cases in FL from unregulated shellfish species or areas
Ciguatoxins (acute toxicity [LD_{50} i.p. mouse] is 350 µg/kg)				
Dinoflagellates				
Ciguatera fish poisoning (CFP); human illness, fish kills, fish disease?	*Gambierdiscus toxicus*	Benthic	South FL	Underreported illnesses; no blooms analyzed for toxin in FL
Cylindrospermopsin (acute toxicity [LD_{50} i.p. mouse] 24 hr = 2.1 mg/kg, 5–6 d = 200 µg/kg)				
Cyanobacteria				
Unknown	*Aphanizomenon ovalisporum*	Freshwater, estuarine, planktonic	FL	Known to be toxic in other regions; implicated in outbreak of severe hepatoenteritis in Australia in 1970s

Impact	Species	Habitat	Distribution	Comments
Alligator, bird, fish, and turtle kills?	*Cylindrospermopsis raciborskii*	Freshwater, planktonic	FL	Blooms occurred during alligator, bird, and fish fills in Lake Griffin, FL
Domoic acid (DA) (acute toxicity [LD_{50} i.p. mouse] is 3.6 mg/kg)				
Diatoms				
Potential for Amnesic Shellfish Poisoning (ASP)	*Pseudo-nitzschia calliantha*	Benthic, tychoplanktonic	FL, Indian River Lagoon	No DA detected in lab tests of FL field samples; no human shellfish toxicity cases in FL
Potential for ASP	*Pseudo-nitzschia delicatissima*	Benthic, tychoplanktonic	Gulf-wide	Low levels of DA detected in lab tests of FL field samples; no human shellfish toxicity cases in FL
Potential for ASP	*Pseudo-nitzschia multiseries*	Benthic, tychoplanktonic	Gulf-wide	No DA detected in lab tests of FL field samples; no human shellfish toxicity cases in FL
Potential for ASP	*Pseudo-nitzschia pseudodelicatissima*	Benthic, tychoplanktonic	Gulf-wide	Low levels of DA detected in lab tests of FL field samples; no human shellfish toxicity cases in FL
Goniodomin A (acute toxicity [LD_{50} i.p. mouse] is 1.2 mg/kg)				
Dinoflagellates				
Fish and invertebrate kills	*Alexandrium monilatum*	Estuarine, coastal, planktonic	Gulf-wide, east FL coast	Caused marine animal mortality in FL, MS, and TX; not implicated in shellfish poisoning (*e.g.,* PSP)
Karlotoxins (not acutely toxic to mice up to 45 mg/kg)				
Dinoflagellates				
Fish kills in nature and in fish farm ponds	*Karlodinium veneficum*	Estuarine, planktonic	FL and TX	Toxic in field and lab studies; known to kill fish at very high cell concentrations (>10^4 cells/mL)
Microcystins (acute toxicity [LD_{50} i.p. mouse] 50–600 µg/kg) *Microcystins are inhibitors of protein phosphatases and are considered tumor promoters in laboratory mice; the provisional WHO standard for microcystin-LR in drinking water is 1 µg/L water.*				
Cyanobacteria				
Potential for wildlife and fish kills, loss of habitat, potable water supply problems, tumor promoter in laboratory mice, human health concerns, hepatotoxins	*Anabaena flos-aquae*	Freshwater, planktonic	FL	No toxic events reported or blooms analyzed for toxin in FL; also shown to produce aphanotoxin in other regions
Potential for animal health problems	*Geitlerinema* sp.	Marine, benthic	FL Keys	Implicated in black disease of corals
Potential for animal health problems	*Leptolyngbya* sp.	Marine, benthic	FL Keys	Implicated in black disease of corals
Potential for wildlife and fish kills, loss of habitat, potable water supply problems, tumor promoter in laboratory mice, human health concerns	*Microcystis aeruginosa*	Freshwater, estuarine, planktonic	FL	Blooms common throughout FL; Lake Okeechobee, August 1987—signs of poisoning in lab mice indicated a hepatotoxin
Unknown	*Microcystis wesenbergii*	Freshwater, planktonic	FL, likely found throughout US	Implicated in poisoning event; blooms not analyzed for toxin in FL

Impact	Species	Habitat	Distribution	Comments
Okadaic acid and derivatives (acute toxicity [LD_{50} i.p. mouse] is 210 µg/kg)				
Dinoflagellates				
Potential for Diarrheic Shellfish Poisoning (DSP); tumor promotion?	*Prorocentrum belizeanum*	Benthic	South FL	No toxic events reported or blooms analyzed for toxin in FL; field and lab studies on strains from other regions have shown toxicity
Potential for DSP; tumor promotion	*Prorocentrum hoffmannianum*	Benthic	North and southwest FL	No toxic events reported or blooms analyzed for toxin in FL; field and lab studies on strains from other regions have shown toxicity
Potential for DSP; tumor promotion	*Prorocentrum lima*	Benthic	Gulf-wide, Atlantic coast FL	No toxic events reported or blooms analyzed for toxin in FL; field and lab studies on strains from other regions have shown toxicity
Potential for DSP; tumor promotion	*Prorocentrum marinum*	Benthic	Gulf-wide, Atlantic coast FL	No toxic events reported or blooms analyzed for toxin in FL
Potential for DSP; tumor promotion	*Dinophysis acuminata*	Coastal planktonic	Gulf-wide	No toxic events reported or blooms analyzed for toxin in FL; field and lab studies on strains from other regions have shown toxicity
Potential for DSP; tumor promotion	*Dinophysis caudata*	Estuarine/coastal planktonic	Gulf-wide, Atlantic coast FL	No toxic events reported or blooms analyzed for toxin in FL; field and lab studies on strains from other regions have shown toxicity
Potential for DSP; tumor promotion	*Dinophysis fortii*	Coastal planktonic	Gulf-wide	No toxic events reported or blooms analyzed for toxin in FL; field and lab studies on strains from other regions have shown toxicity
Potential for DSP; tumor promotion	*Dinophysis* cf. *ovum*	Estuarine/coastal planktonic	Gulf-wide	No toxic events reported or blooms analyzed for toxin in FL; field and lab studies on strains from other regions (TX) have shown toxicity
Potential for DSP; tumor promotion?	*Dinophysis tripos*	Coastal planktonic	Gulf-wide	No toxic events reported or blooms analyzed for toxin in FL
Palytoxins (acute toxicity [LD_{50} i.p. mouse] is 450 µg/kg) / Ostreotoxins				
Dinoflagellates				
Unknown	*Ostreopsis heptagona*	Benthic	South FL	Co-occurs with ciguatera species; no known toxic events in Gulf or FL waters
Unknown	*Ostreopsis lenticularis*	Benthic	South FL	Co-occurs with ciguatera species; no known toxic events in Gulf or FL waters; toxic in lab studies
Unknown	*Ostreopsis siamensis*	Benthic	FL	Co-occurs with ciguatera species; no known toxic events in Gulf or FL waters
Saxitoxins (acute toxicity [LD_{50} i.p. mouse] is 10 µg/kg)				
Cyanobacteria				
Potential for wildlife and fish kills, loss of habitat, human health concerns	*Anabaena circinalis*	Freshwater, estuarine, planktonic	FL	Lake Istokpoga, September 1988—signs of poisoning in lab mice indicated a neurotoxin; implicated in fish kills in St. Johns River 1999

Impact	Species	Habitat	Distribution	Comments
Potential for wildlife and fish kills, loss of habitat, human health concerns	*Aphanizomenon flos-aquae*	Freshwater, planktonic	FL	No toxic events reported or blooms analyzed for toxin in FL
Potential for wildlife and fish kills, loss of habitat, human health concerns	*Cylindrospermopsis raciborskii*	Freshwater, planktonic	FL	Blooms have occurred during alligator, bird, and fish kills in lakes in St. Johns River system
Dinoflagellates				
Saxitoxin puffer fish poisoning (SPFP) and potential for paralytic shellfish poisoning (PSP) incidents	*Pyrodinium bahamense*	Estuarine, coastal, planktonic, benthic	FL	Caused more than 25 SPFP incidents from 2002–2005, high risk of PSP but managed by state agencies; no human cases of PSP reported in Florida
Yessotoxins (acute toxicity [LD_{50} i.p. mouse] is 100–700 µg/kg)				
Dinoflagellates				
DSP-like, fish and invertebrate kills?	*Protoceratium reticulatum* (=*Gonyaulax grindleyi*)	Estuarine, coastal, planktonic	Gulf-wide	No toxic events reported or blooms analyzed for toxin in FL
Potential for shellfish poisoning incidents	*Lingulodinium polyedrum*	Estuarine, coastal, planktonic, benthic	Gulf-wide	No toxic events reported or blooms analyzed for toxin in FL
Potential for shellfish poisoning incidents	*Gonyaulax spinifera*	Estuarine, coastal, planktonic, benthic	Gulf-wide	No toxic events reported or blooms analyzed for toxin in FL
Multiple toxins				
Cyanobacteria				
Potential for coral reef impacts	*Lyngbya* cf. *confervoides*	Marine, benthic	FL	Implicated in sea fan mortalities
Potential for marine animal disease and human health concerns	*Lyngbya majuscula*	Marine, benthic, tychoplanktonic	Gulf-wide, Atlantic coast FL	Lyngbyatoxin, debromoaplysiatoxin (known tumor promoter), aplysiatoxin
Potential for coral reef impacts	*Lyngbya polychroa*	Marine, benthic	FL	Implicated in sea fan mortalities
Potential for wildlife and fish kills, loss of habitat, human health concerns	*Lyngbya wollei*	Freshwater, estuarine; forms benthic mats	FL	Lyngbyatoxin, saxitoxin; implicated in dermatitis in human incidents in FL
Bioactive or potentially toxic				
Cyanobacteria				
Unknown	*Anabaena solitaria* f. *planktonica*	Freshwater, planktonic	FL	Implicated in a poisoning event; occurs as a minor component with other bloom-forming species; no toxic events reported or blooms analyzed for toxin in FL
Unknown	*Anabaenaopsis milleri*	Freshwater, planktonic	FL	No toxic events reported or blooms analyzed for toxin in FL
Unknown	*Aphanocapsa incerta* (formerly *Microcystis incerta*)	Freshwater, planktonic	FL	No toxic events reported or blooms analyzed for toxin in FL

Impact	Species	Habitat	Distribution	Comments
Unknown	*Coelosphaerium kuetzingianum*	Freshwater, planktonic	FL	Implicated in a poisoning event; occurs as a minor component with other bloom-forming species; no toxic events reported or blooms analyzed for toxin in FL
Unknown	*Cylindrospermum* sp.	Freshwater, planktonic	?	No toxic events reported or blooms analyzed for toxin in FL
Unknown	*Microcystis viridis*	Freshwater, estuarine, planktonic	?	No toxic events reported or blooms analyzed for toxin in FL
Unknown	*Microcystis wesenbergii*	Freshwater, planktonic	FL	No toxic events reported or blooms analyzed for toxin in FL
Potential for wildlife and fish kills, loss of habitat, tumor promoter in laboratory mice, human health concerns	*Nodularia spumigena*	Estuarine, planktonic	FL	No toxic events reported or blooms analyzed for toxin in FL
Unknown	*Nostoc* spp.	Freshwater, planktonic, benthic, moist soil	FL	Implicated in poisoning event; blooms not analyzed for toxin in FL
Unknown	*Oscillatoria* spp.	Freshwater, planktonic	FL	No toxic events reported or blooms analyzed for toxin in FL
Unknown	*Planktothrix agardhii*	Freshwater pools, rivers and on moist soil; planktonic, tychoplanktonic	FL	No toxic events reported or blooms analyzed for toxin in FL
Unknown	*Planktothrix rubescens*	Freshwater, tychoplanktonic	FL	No toxic events reported or blooms analyzed for toxin in FL
Benthic animal kills?, low dissolved oxygen?	*Schizothrix calcicola*	Estuarine/ planktonic	FL	Not acutely toxic in lab studies in other regions
Suspected in SE U.S in Avian Vacuolar Myelinopathy	Unnamed species (Family Stigonematales)	Freshwater, epiphytic (on submerged plants)	Central FL	Uncharacterized neurotoxin
Sponge mortality?	*Synechococcus elongatus*	Coastal, estuarine, planktonic	Florida Bay	Mechanical damage or toxicity to sponges
Unknown	*Synechocystis* sp.	Freshwater, planktonic	FL	Hepatotoxins and possible neurotoxins produced; no toxic events reported or blooms analyzed for toxin in FL
Animal kills? Ciguatera?	*Trichodesmium erythraeum*	Offshore, coastal, planktonic	Coastal FL	No toxicity found in FL studies; implicated in fish kills and coral mortality in Australia
Animal kills?	*Trichodesmium thiebautii*	Offshore, coastal, planktonic	Coastal FL	No toxicity found in FL studies
Dinoflagellates				
Associated w/fish kills, not tested for toxicity	*Akashiwo sanguinea*	Estuarine, coastal, planktonic	Gulf-wide, Atlantic coast FL	No toxic events reported or blooms analyzed for toxin in FL
PSP?	*Alexandrium minutum*	Coastal, planktonic	Tampa Bay	Produces saxitoxins elsewhere; no toxic events reported or blooms analyzed for toxin in FL
Unknown	*Coolia monotis*	Benthic	Gulf-wide, Atlantic coast FL	Occurs with ciguatera species; no known toxic events in Gulf or FL waters

Impact	Species	Habitat	Distribution	Comments
Unknown	*Cryptoperidiniopsis brodyi*	Estuarine, planktonic, benthic	FL	No toxic events reported or blooms analyzed for toxin in FL
Fish kills?	*Karenia mikimotoi*	Coastal, planktonic	FL	Known to be toxic in other regions
Fish kills?	*Karenia papillionacea*	Coastal, planktonic	Gulf-wide FL	Field and lab studies on strains from other regions have shown toxicity
Fish kills, low dissolved oxygen	*Karenia selliformis*	Coastal, planktonic	Gulf-wide, Atlantic coast FL	Field and lab studies on strains from other regions have shown toxicity
Unknown	*Karenia* spp.	Coastal, planktonic	FL	
Fish kills?	*Luciella masanensis*	Estuarine, planktonic, benthic	FL	Confirmed at very low incidence; not currently implicated in fish kill or lesion events in FL
Potential for DSP?	*Phalacroma mitra*	Coastal planktonic	Gulf-wide	No toxic events reported or blooms analyzed for toxin in FL
Potential for DSP?	*Phalacroma rotundatum*	Estuarine, coastal, planktonic	Gulf-wide	No toxic events reported or blooms analyzed for toxin in FL
Animal effects?	*Prorocentrum rhathymum* (=*P. mexicanum* in part)	Benthic	Gulf-wide	No toxic events reported or blooms analyzed for toxin in FL
Fish kills? Physiologically impaired shellfish	*Prorocentrum minimum*	Coastal, estuarine, planktonic	Gulf-wide, Atlantic coast FL	No toxic events reported or blooms analyzed for toxin in FL
Fish kills?	*Pfiesteria piscicida*	Estuarine, planktonic, benthic	FL	Confirmed at very low incidence; not implicated in fish kills in FL
Fish kills in aquaria	*Pfiesteria* sp.	Benthic, planktonic	?	May be responsible for fish kills in tropical saltwater aquaria
Fish kills?	*Pseudopfiesteria shumwayae*	Estuarine, planktonic, benthic	FL	Confirmed at very low incidence; not implicated in fish kill events in FL
Fish kills, low dissolved oxygen	*Takayama pulchella*	Estuarine, planktonic	Southeast FL, Indian River	Implicated in a 1996 fish kill
Fish kills, low dissolved oxygen	*Takayama tasmanica*	Estuarine, planktonic	Southeast FL, Indian River	Implicated in a 2004 fish kill
Prymnesiophytes				
Fish kills?	*Chrysochromulina* spp.	Coastal, planktonic	Gulf-wide	Cytolytic toxins?
Fish kills	*Prymnesium parvum*	Coastal, estuarine, planktonic	Gulf-wide	Fish kills in TX and FL, and known toxic strains
Fish kills	*Prymnesium saltans*	Coastal, estuarine, planktonic	Gulf-wide	Fish kills in FL, and known toxic strains
Raphidophytes				
Fish kills?	*Chattonella antigua*	Coastal, planktonic	FL	No toxic events reported or blooms analyzed for toxin in FL
Fish kills	*Chattonella subsalsa*	Coastal, planktonic	FL	Lab studies on strains from other regions have shown toxicity
Fish kills	*Chloromorum toxicum* (formerly *Chattonella* cf *verruculosa*)	Coastal, estuarine, planktonic	FL	Lab studies on strains from other regions have shown toxicity
Fish kills?	*Fibrocapsa japonica*	Coastal, planktonic	FL	Lab studies on strains from other regions have shown toxicity
Fish kills	*Heterosigma akashiwo*	Coastal, planktonic	FL	Lab studies on strains from other regions have shown toxicity

Reproduced from *Harmful Algal Blooms in Florida.* Submitted to Florida's Harmful Algal Bloom Task Force by the Harmful Algal Bloom Task Force Technical Advisory Group and prepared by K. A. Steidinger, J. H. Landsberg, C. R. Tomas, and J. W. Burns, March 1999, 62 p. Updated by J. H. Landsberg, FWC–FWRI; K. A. Steidinger, FIO; and J. Wolny, FIO; February 2008.

Appendix E

Examples of Guidelines for Cyanobacteria in Recreational Waters[a]

Country	Guideline
Australia	Guidelines are designated for cyanobacteria and algae in fresh waters and coastal and estuarine waters, and corresponding management actions including alert levels and staged response have been outlined. Fresh recreational water bodies have multiple guideline values based on known risks associated with toxins and health risk from exposure to cyanobacteria. Management Action Levels: Level 1: Microcystin levels ≥10 µg/L; toxic *Microcystis aeruginosa* ≥50,000 cells/mL; biovolume equivalent of ≥4 mm^3/L for the combined total of all cyanobacteria where a known toxin producer is dominant in the total biovolume; or Level 2: ≥10 mm^3/L total biovolume of all cyanobacteria where known toxins are not present; or Level 3: Cyanobacterial scums consistently present. Coastal and estuarine recreational water bodies should not contain ≥10 cells/mL *Karenia brevis* and/or have *Lyngbya majuscula* and/or *Pfiesteria* present in high numbers. In 2008, the National Health and Medical Research Council (NMHRC) released the document "Guidelines for Managing Risks in Recreational Waters," addressing cyanobacteria and algae in fresh, coastal, and estuarine waters. The document is available for download on NMHRC's Web site, http://www.nhmrc.gov.au/publications/synopses/eh38.htm
Czech Republic	No requirements to analyze cyanotoxins. The responsibility to monitor water quality lies with the owners or managers of the recreational sites. Warning or alert categorization system adopted via ordinance of National Health Institute (Methodical advice CSN 757712, TNV 757717). More than 20,000 cells/mL is considered the first warning level. If more than 100,000 cells/mL are present, the reservoir should be closed for public recreation.
France	Three levels of management responses are identified depending on the concentration of cyanobacteria: Level 1: At <20,000 cells/mL ± 20%, the majority of which are cyanobacteria, recreational activities are allowed to continue and users are informed by posters on site. There is, however, no standardized information. Monitoring is intensified to fortnightly sampling, counting, and species identification. Level 2: At 20,000–100,000 cells/mL: microcystins are analyzed. If the toxin concentration MC-LR–equivalents is >25 µg/L, swimming is prohibited. The only watersports allowed are those like rowing with minimum water contact. There are, however, no restrictions at all for professional athletes. Level 3: When cyanobacterial scum appears in bathing areas, all activity in the water is prohibited. In 2003, following a recommendation by the public health service, a decision diagram was set up to allow site managers and health services responsible for routine surveillance to collaborate. In water bodies with persistently high algal concentrations, based on visual and microscopic observations, a stricter monitoring system is implemented.

Country	Guideline
Germany	No mandatory guidelines. These are the recommended guidelines using a decision matrix: Visible scum, "greenish" streaks, or discoloration: publish warning notices (targeted to user groups) and discourage bathing; consider temporary closure of the bathing area. Samples taken at secchi depth <1 m, total P > 20–40 µg/L, cyanobacteria dominant, chlorophyll *a* >40 µg/L, and microcystin levels <10 µg/L: evaluate through routine monitoring; microcystin levels >10 µg/L and <100 µg/L: publish warning notices (targeted to user groups) and discourage bathing; consider temporary closure of the bathing area; microcystin levels >100 µg/L: publish warning notices and discourage bathing; recommend temporary closure of the bathing area. The guidelines also suggest that microcystin concentrations can be expected to be similar to those found for chlorophyll *a* when cyanobacteria are dominant. Therefore, in such situations, warnings should be issued at >40 µg/L chlorophyll *a*, or the site should be temporarily closed at >100 µg/L.
Hungary	Cyanobacterial blooms are regulated based on the chlorophyll *a* concentration. The proposed limit for chlorophyll *a* is 25 µg/L and the still-acceptable limit is 75 µg/L. [273/2001(XII.21) Governmental Ordinance on the Quality of Natural Bathing Waters]
Italy	In 1998, the Ministry of Health provided a list of toxic algae and cyanobacteria of concern, analytical methodologies, and recommended a limit of 5,000,000 cells/L of toxic algal species as a safe level for bathing activities.
Netherlands	No official guidance value, but recommend an exposure limit of 20 µg/L. These provisional guidelines are used by many provinces: MC-LR >10 µg/L: issue warning MC-LR >20 µg/L: issue warning and continue monitoring; if levels are persistently high, close bathing facility Presence of scums: at least issue a warning and continue monitoring Values based upon the tolerable daily intake in food (MC-LR <0.04 µg per kg bodyweight), from which the provisional WHO guideline for drinking water (MC-LR <1 µg/L) was derived, and assuming that a swimmer ingests 100 mL of water (and bathes 365 days per year—more likely this would be less than 35 days), an exposure limit of 20 µg MC-LR per liter of bathing water is derived.
Poland	In 2002, the Polish Ministry of Health added the presence of cyanobacteria to the requirements for monitoring bathing-water quality. The presence of cyanobacterial blooms is determined by observation of water color, turbidity, and odor. Monitoring is done biweekly from April until the end of September. The required analysis does not include a determination of total phosphorus and nitrogen (parameters that determine cyanobacterial growth) or the quantitative measurement of chlorophyll *a* concentrations.

[a]Adapted from Burch, 2008.

Appendix F

Bibliography of Significant Literature

Brevetoxins

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Appendix G
Glossary

amnesic shellfish poisoning (ASP)	illness caused by eating shellfish that have fed on diatoms producing the toxin domoic acid; symptoms include a decreased reaction to pain and short-term memory loss; has caused deaths
anoxia	absence of oxygen
aphasia	impairment or loss of speech or speech comprehension
aquaculture	the growth of freshwater and marine organisms for food on a commercial scale in a confined area or volume of water
armored	refers to dinoflagellates that are covered with adjoining cellulose (or other polysaccharide) plates (thecate); plate pattern is characteristic for armored genera
arthralgia	joint pain
asthenia	absence or lack of energy or strength
ataxia	loss of muscular coordination
autotroph	an organism that makes its own organic food via photosynthesis or chemosynthesis
ballast water	water carried in a ship's hold to give the craft stability, usually collected at one port and released at a second port
bathymetry	the measurement of depth in bodies of water
benthic	pertaining to all undersea bottom terrain, regardless of water depth
beta testing	hardware or software testing of a new product before releasing commercially; usually conducted by customers
biota	the living portion of a given area including animals, plants, fungi, and microorganisms
biotoxin	a biologically produced toxin
bivalve mollusk (mollusc)	an organism with a two-part shell (*e.g.,* oyster or clam) belonging to the Phylum Mollusca
bloom	a higher-than-normal population of phytoplankton or microalgae within the water column
brackish	water of less than normal oceanic salinity, usually ranging from 0.5 to 17 PSU but can have up to 32 PSU
brevetoxins	a suite of neurotoxins reported (and verified) from *Karenia brevis*
carcinomas	malignant neoplasia derived from epithelial tissue
chloroplast	the cellular organelle in which photosynthesis takes place
ciguatera fish poisoning (CFP)	a human disease caused by eating certain tropical fish that contain ciguatoxin and its derivatives; the toxins originate in dinoflagellates; more than 400 tropical fish species are implicated; affects the gastrointestinal and neurological systems; the characteristic symptom is hot–cold reversal

ciguatoxin	a toxin produced by the benthic dinoflagellate *Gambierdiscus toxicus*
control (of HABs, see mitigation)	efforts to reduce or confine the size, intensity, or duration of a bloom
copepods	any of various small marine and freshwater crustaceans of the order Copepoda
CUSUM	a method to graphically represent the cumulative sums of two related sets of data
crustacean	aquatic arthropods having segmented bodies, chitinous exoskeletons, and paired jointed limbs; including lobsters, crabs, shrimps, and barnacles of the order Crustacea
depuration	the process of removing contaminants from seafood
desquamation	shedding of skin
diatom	planktonic microalgal form with siliceous shell (shaped like a pillbox); occurs as a single cell or in a chain of connected shells; capable of photosynthesis
diarrheic shellfish poisoning (DSP)	illness caused by eating shellfish that have fed on *Dinophysis* or *Prorocentrum* dinoflagellates, which produce a suite of toxins, including okadaic acid, dinophysistoxins, and pectenotoxins; causes gastrointestinal disorders; not life-threatening
dinoflagellate	unicellular microorganisms with two flagella (at some time during the life cycle); cells can be armored or unarmored; approximately half photosynthesize; Class Dinophyceae, Phylum Pyrrophyta, Division Dinoflagellata
dinophysistoxin	toxins produced by *Dinophysis* or some *Prorocentrum* species
domoic acid	toxin produced by *Pseudo-nitzschia* and *Nitzschia* species
dysesthesia	impairment of sensation from normal stimuli short of anesthesia
ELISA	enzyme-linked immunosorbent assay; a chemical method for detection of toxins such as brevetoxin
EpiCom	FDOH health information system
epizootic	epidemic or outbreak of disease in a population of animals
estuary	a semi-enclosed body of water that is connected to the open ocean, within which freshwater from the land mixes with seawater
etiological	relating to the causatory agents of a disease or illness
eutrophic	a body of water that is rich in nutrients
filter feeder	an organism that obtains food by filtering particles from the water column; also called a suspension feeder
flagella (plural), flagellum (singular)	a long, whip-like projection used for locomotion
genotoxic	toxic or damaging to DNA
gymnodinioid	a type of unarmored dinoflagellate (*e.g., Gymnodinium* cells)
hemolysin	a toxin that lyses or destroys red blood cells
hepatotoxin	a toxin poisonous to the liver
heterotroph	an organism that ingests and absorbs organic materials for carbon source and energy

high performance liquid chromatography (HPLC)	an analytical laboratory technique using chemical interactions to identify, separate, purify, or quantify specific compounds
hypoxia	decrease below normal levels of oxygen, short of anoxia
ichthyotoxin	a toxin poisonous to fish
indigenous	native; living or occurring naturally in a specific environment
in situ	in the natural or original place; site of origin
LC–MS	liquid chromatography–mass spectrometry; a chemical method for detection of toxins such as brevetoxin
LD_{50}	lethal or life dose; dose required to kill 50 percent of the exposed organism or population
littoral	the shore or region affected by high and low tides
macroalgae	nonmicroscopic alga; observable to the eye
maitotoxin	a toxin produced by the benthic dinoflagellate *Gambierdiscus toxicus*
Merlin®	FDOH electronic communicable disease reporting system
microalgae	microscopic aquatic plants; can live free in the water column or attached to sediments, plants, and even animals
microcystin	a hepatotoxin produced by certain cyanobacteria species
mitigation (of HABs, see Control)	efforts to minimize or reduce the negative environmental, economic, social, or public health impacts of HABs
molluscan shellfish	type of shellfish that belong to the Phylum Mollusca (*e.g.,* oysters, clams, and gastropods)
mouse bioassay (MBA)	laboratory technique used to determine total toxicity of samples. *Note:* does not determine the causative agent, toxin, or group of toxins
myalgia	muscle pain or tenderness; may be chronic or temporary
nanogram	one billionth of a gram
neritic	related to the ocean zone from the low tide line to the edge of the continental shelf
neurotoxic shellfish poisoning (NSP)	illness caused by eating shellfish that have accumulated brevetoxin and its derivatives; not fatal; the main symptoms include tingling or numbness of the lips, tongue, throat, hands, and feet
neurotoxin	a toxin that acts on nerve cells
nutrient	any substance required by an organism for normal growth and maintenance
oceanic	waters in the open ocean, beyond the continental shelf
okadaic acid	a toxin produced by *Prorocentrum* and *Dinophysis* species
oligotrophic	waters that are low in nutrients and biomass
oomycete	fungi that produce oospores for reproduction; nonphotosynthetic; resemble algae
papilloma	a benign epithelial tumor

paralytic shellfish poisoning (PSP)	illness caused by eating shellfish containing toxic levels of saxitoxin and its derivatives; neurological symptoms include tingling, numbness, and burning of lips and fingertips; in severe cases, respiratory paralysis can cause death within 24 hours
paresthesia	abnormal sensation of the skin; *e.g.,* tingling or burning
Pfiesteria species	belongs to the genus *Pfiesteria*
Pfiesteria-like	morphologically similar to *Pfiesteria;* can be associated with fish kills
phycotoxin	algal toxin
physiographic	the physical features of a site; *i.e.,* topography, soils, water resources, climate, and vegetative cover
phytoplankton	small plant organisms that drift in the water column; they are too small to resist currents
planktonic	refers to those microscopic organisms that live floating or drifting, suspended in the water column
ppb	parts per billion; the concentration of a substance per billion units in which it is being measured; *e.g.,* water
ppm	parts per million; the concentration of a substance per million units in which it is being measured; *e.g.,* water
psu	practical salinity units; the total amount of dissolved salts in water determined by its electrical conductivity relative to a prescribed standard (**Note:** Some authorities recommend no units)
prorocentrolide	a toxin produced by *Prorocentrum* species
protista	diverse kingdom of simple organisms; includes diatoms and dinoflagellates
pruritus	itchiness
red tide	a harmful algal bloom (HAB); refers to a bloom of toxic or harmful marine microorganisms that may color the water; toxins may also be released
reef fish	finfish living on or near a coral (or artificial) reef
saxitoxin (STX)	highly toxic neurotoxin that causes PSP or SPFP; produced by the dinoflagellate *Pyrodinium bahamense*
saxitoxin puffer fish poisoning (SPFP)	illness caused by eating puffer fish containing toxic levels of saxitoxin and its derivatives: neurological symptoms include tingling, numbness, and burning of lips and fingertips; in severe cases, respiratory paralysis can cause death within 24 hours (no fatalities known in USA)
shellfish	can refer to marine organisms belonging to the Phylum Mollusca (*e.g.,* clams and other bivalves) and the Subphylum Crustacea of the Phylum Arthropoda (*e.g.,* crabs and lobsters); generally, shellfish refers to mollusks
siliceous	containing silica
sonolysis	the destruction or breakage of cells using high-frequency sound waves
STORET	(STOrage and RETrieval) EPA repository for water quality, biological, and physical data.
strain	a specific isolate of organisms within the same species

taxa	classification for a grouping of organisms
trophic	levels of the food chain
tychoplanktonic	benthic organisms accidentally swept up into the water column
urticaria	hives; raised itchy red areas of skin
viscera	the internal organs particularly contained within the chest and abdomen; includes lung, heart, and digestive organs (*e.g.,* stomach, kidney)
wind field	the three-dimensional spatial pattern of winds
zooplankton	animal component of the planktonic community

Appendix H
Acronyms and Abbreviations

ACHA	American College Health Association
ADEQ	Arizona Department of Environmental Quality
AHCA	Agency for Health Care Administration
APHIS	Animal and Plant Health Inspection Service
ASP	amnesic shellfish poisoning
AST/ALT	alanine aminotransferase/aspartate aminotransferase
ATP	Aquatic Toxins Program
AWWA	American Water Works Association
BT	bacterial
CCFHR	Center for Coastal Fisheries and Habitat Restoration (NOAA)
CCL	contaminant candidate list
CDC	Centers for Disease Control and Prevention
CFP	ciguatera fish poisoning (tropical fish poisoning)
CHD	county health department
COPD	chronic obstructive pulmonary disease
CTX	ciguatoxin
DSP	diarrheic shellfish poisoning
ECOHAB	Ecology and Oceanography of Harmful Algal Blooms
EIA	enzyme immunoassay
ELISA	enzyme-linked immunosorbent assay
EPA	Environmental Protection Agency
EPCHC	Environmental Protection Commission of Hillsborough County
EWMA	exponentially weighted moving average
F.A.C.	Florida Administrative Code
FAQ	frequently asked question
FDA	Food and Drug Administration
FDACS	Florida Department of Agriculture and Consumer Services
FDENS	FDOH Emergency Notification System
FDEP	Florida Department of Environmental Protection
FDOH	Florida Department of Health
FHABTF	Florida Harmful Algal Bloom Task Force
FIO	Florida Institute of Oceanography
FP	fibropapillomatosis
FPIC	Florida Poison Information Center
F.S.	Florida Statute
FWVSS	Food, Water and Vector-borne Surveillance System
FWC	Florida Fish and Wildlife Conservation Commission
FWCLE	Florida Fish and Wildlife Conservation Commission Law Enforcement
FWRI	Fish and Wildlife Research Institute
GoM	Gulf of Mexico
GEOHAB	Global Ecology and Oceanography of Harmful Algal Blooms
GWL	GreenWater Laboratories / CyanoLabs
HAB	harmful algal bloom
HABISS	Harmful Algal Bloom-related Illness Surveillance System
HABHRCA	Harmful Algal Bloom and Hypoxia Research Control Act
HAL	health advisory level

HARRNESS	Harmful Algal Research and Response National Environmental Science Strategy
HIPAA	Health Insurance Portability and Accountability Act
HPLC	high performance liquid chromatography
HPLC/MS	high performance liquid chromatography/mass spectrometry
ICP	infection control practitioner
IDNR	Iowa Department of National Resource
IDPH	Iowa Department of Public Health
IAEA	International Atomic Energy Agency
IEC	information, education, and communication
IFAS	Institute of Food and Agricultural Sciences
IOC	Intergovernmental Oceanographic Commission
IRL	Indian River Lagoon
ISSHA	International Society for the Study of Harmful Algae
ISSC	Interstate Shellfish Sanitation Conference
KADL	Kissimmee Animal Diagnostic Laboratory
LC–MS	liquid chromatography–mass spectrometry
LD50	lethal or life dose 50
LOAEL	lowest observable adverse effect level
MAC	maximum acceptable concentration
MBA	mouse bioassay
MC-LR	microcystin-LR
MCWTP	Manatee County Water Treatment Plant
MML	Mote Marine Laboratory
MMWR	Morbidity and Mortality Weekly Report
MU	mouse units
NCEH	National Center for Environmental Health
NEP	National Estuary Program
NIEHS	National Institute of Environmental Health Science
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NRDM	National Retail Data Monitor
NSF	National Science Foundation
NSP	neurotoxic shellfish poisoning
NSSP	National Shellfish Sanitation Program
NTAC	National Technical Advisory Committee
NWFSC	Northwest Fisheries Science Center
OA	okadaic acid
ODHS	Oregon Department of Health Services
OTC	over-the-counter
PbTx	brevetoxin
PCA	personal care assistance
PCC	Poison Control Center
PCR	polymerase chain reaction
PHTP	public health technical panel
PLS	*Pfiesteria*-like species
ppb	parts per billion
ppm	parts per million
PFP	puffer fish poisoning
PSP	paralytic shellfish poisoning
PSU	practical salinity units (some authorities recommend no units)
QSAR	quantitative structural activity relationships
RDC	rapid data collector
RSD	red sore disease
SAV	submerged aquatic vegetation
SDWA	Safe Drinking Water Act

SEAS	Shellfish Environmental Assessment Section
SFWMD	South Florida Water Management District
SJRWMD	St. Johns River Water Management District
SPFP	saxitoxin puffer fish poisoning
SPI	specialist in poison information
spp.	species (plural)
START	Solutions to Avoid Red Tide
STX	saxitoxin
TAG	technical advisory group
TDI	tolerable daily intake
TTX	tetrodotoxin
TWQR	total water quality range
UCMR	unregulated contaminant monitoring regulation
UF	University of Florida
UM	ulcerative mycosis
U of M	University of Miami
UNCW	University of North Carolina at Wilmington
UNESCO	United Nations Educational, Scientific and Cultural Organization
USAMRIID	United States Army Medical Research Institute for Infectious Diseases
USDOE	United States Department of Interior
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WHO	World Health Organization
WHOI	Woods Hole Oceanographic Institution
WMD	Water Management District

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Fish Kill Hotline
1-800-636-0511
http://research.myfwc.com/fishkill/submit.asp

Poison Control
1-888-222-1222
http://www.fpicn.org/

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