During summer 2005, many Floridians noticed bright green scum on the surfaces of lakes, rivers and estuaries (Figure 1). Newspaper articles reported widely on the ‘toxic blue-green algae blooms’ observed in the St. Lucie River, Caloosahatchee River, St. Johns River, Lake Okeechobee and many other systems. This situation resembled an event that occurred four years earlier (see WaterWorks 2001 Volume 5, No.4, The Toxic Algae Threat in Florida: A Tempered View, by Ed Phlips). Given the publicity surrounding this year’s blooms and concerns about ecosystem and human health impacts expressed by citizens and management agencies, we revisit the issue and address four key questions.

1. What are toxic blue-green algae blooms and why do they occur?

Blue-green algae are actually microscopic bacteria containing photosynthetic pigments that produce the characteristic color that gives rise to their name. Microbiologists classify them as “cyanobacteria,” but the name blue-green algae stems from their ability to carry out the same type of photosynthesis as most algae. Blue-green algae are among the oldest life forms on earth, with records dating back over 3 billion years. In many water bodies throughout the world, blue-green algae are the dominant photosynthetic organism, and they occur naturally in almost all of Florida’s aquatic ecosystems.

Hundreds of species of blue-green algae inhabit Florida’s waters, and several can produce toxins, including neurotoxins, which affect animals’ central nervous systems, and hepatotoxins, which affect animals’ livers and digestive tracts. Neurotoxins have rarely been detected in Florida, and they are normally associated with certain species and strains of blue-green algae in the genus Anabaena (Figure 2a). Hepatotoxins, on the other hand, have often been detected in Florida, most commonly in association with the blue-green algal species Microcystis aeruginosa (Figure 2b) and to a lesser extent with species of Cylindrospermopsis (Figure 2c). Microcystin was the focus of the greatest concern during summer 2005, due to the high levels detected in lakes, rivers and estuaries suffering from extensive algal blooms. Microcystin levels of over 500 micrograms/liter were observed in some samples of surface scum. These values exceed the World Health Organization guidelines of 1 microgram/liter for drinking water. Although untreated lake water is rarely consumed in Florida, the high levels of microcystin observed in some blooms raise important questions about impacts on the ecology of affected aquatic environments and potential threats to human health.

Algae can bloom wherever the temperature is high enough and nutrients and light are abundant. Shallow waters in subtropical Florida, especially the hundreds of shallow lakes that dot the landscape, often provide the temperature and light needed for blooms. The necessary nutrients can come from several sources, some natural and some of human origin. The phosphorus-rich geological formations present in many regions of Florida provide some of the fuel for blooms. Human development and other activities have added nutrients in many areas and heightened the bloom potential. The latter trend began over 100 years ago, has accelerated in parallel with the burgeoning of Florida’s population, and correlates with an increase in blooms. However, the frequency and intensity of blooms have not increased linearly. The occurrence and strength of algal blooms wax and wane, in large part due to changes in weather. Weather influences the severity of blooms by changing inputs of nutrients in runoff, altering the amount of water in lakes, and changing the flow of rivers. The impressive blooms in 2005 can be attributed, in part, to a combination of ideal meteorological conditions for blooms, analogous to a “perfect storm.”

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Figure 1. A surface bloom caused by the cyanobacteria Microcystis in the St. Lucie River during July 2005 (photo courtesy Richard Harvey, USEPA)
2. Are toxic cyanobacterial blooms hazardous to people, fish and other animals?

Unlike marine algal toxins associated with some red tides, which definitely have been linked to human health issues and animal deaths, only one person’s death has been linked with cyanobacterial toxins. In this case, water contaminated with toxins was used for dialysis of a patient with kidney failure in Brazil. We know little about non-lethal effects on human health aside from rare reports of illness related to people drinking water with high toxin levels, primarily in Australia. Beyond drinking contaminated water, potential routes for exposure to algal toxins include accidental consumption of water while swimming, inhaling aerosolized toxins (e.g., showering with raw lake water), eating contaminated fish or shellfish, and prolonged exposure of skin to algal scums. However, knowing the potential routes for exposure and understanding health effects are quite different things. Part of the problem is that blooms contain more than just toxic algae. They tend to be a mixture of bacteria, algae, fungi and chemicals, any one of which could cause the aforementioned effects. At this time, the effects of short-term and long-term exposure are poorly understood, and they remain a subject of ongoing research in Florida and other places where cyanobacterial toxins commonly occur.

There have been numerous reports of dogs, cows and other domesticated animals dying after drinking water from lakes or ditches with dense cyanobacterial blooms and some reports of dead waterfowl coincident with bloom events. Research on the effects of toxins has occurred primarily in laboratories, where particular species of animals, both terrestrial (including mice) and aquatic (including invertebrates and fish), have been exposed to toxins. These studies indicate that high levels of toxin can impact behavior, ability to gather food, normal functioning of organs, reproductive success, and survival. Although the results of these studies provide critical information on the effects of toxins on certain species of animals, attempts to extend these results to predict the response of natural aquatic ecosystems have been limited, and such predictions remain a challenging research issue. Defining the impact of toxins in natural environments becomes complicated because algal blooms can also be associated with a host of other effects that negatively impact animal communities. Clearly, much remains to be learned about how toxins contribute to biological stress in aquatic environments during algal blooms.

3. Can blooms be reduced in occurrence, prevented, or even eliminated?

The most direct way to prevent or reduce the occurrence of blooms is to reduce the availability of nutrients that fuel the growth of algae. The feasibility of reducing nutrient availability in large natural aquatic ecosystems depends, in large part, on their sources. Some of the most dramatic reductions in algal blooms have involved the control of point sources of nutrients.
Florida’s economy is inextricably linked to its coastal and marine resources, and balancing their use and protection is one of the critical challenges facing the state, now and into the future. Florida is the number one U.S. destination for marine recreation activity, including recreational boating. In addition to the nearly one million boats registered in Florida (about one per 17 residents), an estimated 400,000 tourist boats use state waterways annually. Indeed, since 1970, the 82% increase in the number of registered boats that ply Florida’s waterways has outpaced the 56% boom in population.

The increasing use of Florida’s waterways has created competing and conflicting pressures among boaters, waterfront users, and the natural environment. The Boating and Waterway Management Program (BWMP)—a joint venture of Florida Sea Grant and the Department of Fisheries and Aquatic Sciences—is intended to help the state meet such challenges. The program is led by Dr. Robert Swett. Bob and his colleagues, Dr. Charles Sidman and David Fann, have built a solid foundation of boating and waterway policy, applied research, and outreach activities. A key to the program’s success has been collaborative partnerships established both within UF and with a diversity of federal, state, regional, and local stakeholders.

One long-term project began when Florida’s West Coast Inland Navigation District (WCIND) and the BWMP recognized the need for comprehensive waterway management and planning, similar in scope and purpose to terrestrial efforts. In response, they developed a science-based Regional Waterway Management System (RWMS), sanctioned by the State of Florida, that resulted in innovative state policy meant to balance the simultaneous use and protection of estuarine environments, while maintaining the economic vitality of coastal communities.

The RWMS combines on-water censuses of boat locations and characteristics with surveys of water depths in channels. Boat drafts and waterway depths are analyzed in a geographic information system (GIS) to identify, for individual channels, which boats are blocked at mean lower low water, and by how much; and conversely, for each boat, which channel segments may block it and by how much. Counties use this information, along with statistical analyses and recommendations, to identify and quantify actual or potential problems. The scientific approach provides unbiased information for rational, objective waterway management and allows local decision-makers to assign maintenance priorities on a regional basis.

Field applications of the RWMS along 1000+ miles of waterways in Manatee, Sarasota, and Lee Counties led to Chapter 62-341.490 of Florida’s Administrative Code: “Noticed General Permit for Dredging by the West Coast Inland Navigation District.” The rule applies to 51 boat source areas (canal systems, for example) that have high-priority needs for maintenance dredging and minimal potential for environmental impacts, as identified by the RWMS. To qualify for the general permit, the rule explicitly states that environmental restoration and enhancement projects must comply with the science-based procedures and methods outlined in technical documents developed by the BWMP.

The adoption of the RWMS by the State of Florida and implementation of the Administrative Code rule demonstrate that sound science and its extension can guide management of state waterways. Benefits include: (1) state policy based on the “best available science,” (2) more efficient and effective dredging and waterway maintenance, (3) savings in dollars and staff time, and (4) better public policy through holistic, ecologically-based decision making that is predictable, fair, and cost effective.

Links:
http://edis.ifas.ufl.edu/SG067
http://www.flseagrant.org/program_areas/boating/index.htm

Program lead Bob Swett applies fieldwork and analysis to tackle daunting problems facing Florida’s waterways and a growing recreational boating population.
Ivy Baremore began her graduate work with Dr. Debra Murie in the fall of 2004. Her Master’s thesis focuses on the trophic dynamics of the Atlantic angel shark, *Squatina dumerili*. The Atlantic angel shark is a bottom-dwelling shark that inhabits waters of the Gulf of Mexico and the U.S. Atlantic Ocean. Of the 11 described species of angel sharks found throughout the world, the Atlantic angel shark is the only one known to occupy the Gulf of Mexico. Due to a lack of biological information, it is listed as a prohibited species by the Fisheries Management Plan for Sharks (NMFS 1993), which means that it cannot be landed by fishers in U.S. waters.

In a collaborative effort, angel sharks caught by trawl vessels from Raffield’s Fishery (Port St. Joe, Florida) are collected for biological research by the National Oceanic and Atmospheric Administration’s (NOAA) Fisheries Service in Panama City, Florida. A special scientific exempted fishing permit was issued to Raffield’s, which allows them to keep the sharks for research purposes. This endeavor has provided the first scientific data on this species, and it continues to be a valuable resource. Ivy’s previous work as a biological technician with NOAA Fisheries and an ongoing collaborative association with the Panama City laboratory allow her to continue research on this species at the University of Florida.

Because the Atlantic angel shark is a benthic ambush predator that is caught in trawls, it may be possible to describe prey availability by quantifying the trawl catch (Fig 1). Inferences about prey selectivity can be made by comparing the prey items caught in trawls to the items found in angel shark stomachs. This information is important because fish with highly selective diets are likely to be more vulnerable to changes in food availability due to fishing or environmental variations. Although the Atlantic angel shark is currently off-limit to fishers, this information may help managers predict how angel sharks respond to fishing mortality directed at their prey.

Preliminary results from two sampling trips show that angel sharks feed primarily on bony fishes (77% by occurrence), including croakers, goatfishes, lizardfishes, porgies, seabasses (Fig. 2), eels, scorpionfishes, snappers, and hakes. Squid are also an important component of the diet (14%), and some crustaceans, such as shrimps and crabs, are also consumed (9%). The diet does not appear to be highly specialized, and it reflects some of the most abundant species found in the trawl catches. Other areas of Ivy’s thesis research concentrate on testing for selection of prey by size and assessing changes in diet as sharks grow and mature (ontogenetic shifts). Gaining knowledge of the trophic dynamics of the Atlantic angel shark will help to ensure proper management of this species in the future.


![Trawl bycatch](Figure 1)

![Seabass from stomach contents](Figure 2)
Researchers hope to reel in high-performance perch

The following article, written by Candace Pollock of Ohio State University, focuses on the research of Geoff Wallat, a 1998 MS graduate of the Dept. of Fisheries and Aquatic Sciences (faculty advisor Frank Chapman).

Ohio State University Ohio Agricultural Research and Development Center aquaculturists Han-Ping Wang and Geoff Wallat are leading a team of researchers in a U.S. Department of Agriculture-funded project to make sure that Ohio’s most popular fish - yellow perch - meets those requirements.

“Markets want fish that are 8-11 inches long and produce a 4-5 ounce filet. And it’s expected that 90 percent of the fish reach that size within 18 months,” said Wallat with OSU South Centers at Piketon, Ohio. “In Ohio, usually only 50 percent of pond-raised perch reaches that market size and it takes them 18 months to do it. The purpose of our study is to improve the consistency of size and reduce the time it takes to reach that size.”

In order to do that, researchers are crossbreeding strains of yellow perch found throughout the country, in the hope that genetics will create the perfect fish. Strains of yellow perch from Maine, New York, Pennsylvania, Wisconsin, Nebraska, North Carolina and Ohio are being studied through a number of crossbreeding variations to determine which, if any, would make a faster-growing, larger-growing yellow perch.

“It’s not uncommon for pond-raised perch to have variable growth rates,” Wallat said. “But because of those variable growth rates, it takes longer for some of the fish to reach market size and the population that does reach market size is not high enough for market standards. There are also some problems with semi-wild brood stock being used with pond-raised fish, which also may inhibit optimum market size. Not a lot of work has been done with genetics and we are hoping that genetics will produce a more uniform fish.”

In a recent study conducted at Purdue University, data has shown that at water temperatures of 72 to 74 degrees Fahrenheit, North Carolina strains of yellow perch grew quicker than several other geographical strains being studied. Preliminary data from the Ohio State study has shown that the Ohio strain has outperformed geographically related strains such as Pennsylvania and New York.

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Assessment of the Southern Snapper Fishery in Queensland, Australia

Dr. Mike Allen (FAS/IFAS) is visiting Australia on a sabbatical where he is working with the stock assessment team at the Southern Fisheries Centre, Queensland Department of Primary Industries.

Dr. Allen is conducting an assessment of the Queensland southern snapper P. auratus fishery. Southern snapper support important recreational and commercial fisheries throughout New Zealand and central/south Australia, and represent the largest recreational fishery south of the Great Barrier Reef. In Queensland, recreational landings of southern snapper exceed commercial landings by a factor of two to four.

The southern snapper is associated with rocky reefs at water depths ranging from 10 to 200 meters. The species has a long life span with low natural mortality (M=0.1 to 0.15), and thus are potentially vulnerable to overfishing. There is cause for concern because most harvest is focused on fish ages 2-4, and fish over age 10 are rare in the catch.

Dr. Allen is using a stochastic stock reduction analysis (SRA) to assess the stock status and potential remedial management actions. The SRA uses historical and current fishery data to estimate what past recruitment (i.e., number of age-1 fish per year) would have been required to produce the landings history and result in the current stock status (e.g., population size or age structure).

His results show that the southern snapper stock is heavily fished with fishing mortality currently exceeding sustainable levels. The current population biomass is predicted to be only 20-30% of the virgin biomass levels. The simulations indicate that measures to reduce fishing mortality such as size limits and bag limits would have to be very restrictive to reverse a declining population trajectory.

Because very restrictive size or bag limits would cause more fish to be caught and released by anglers, the impact of discard mortality could have strong implications for the snapper stock. Dr. Allen is modeling the impact of discard mortality on fish caught and released and evaluating the potential for discard mortality to negate the benefits management actions. If discard mortality would nullify benefits of size/bag limits, then fishery managers would need to consider time/area closures to protect the stock.

Results of this work will be used to improve the management of southern snapper fishery in Queensland. Dr. Allen returns to Gainesville this month and will present a seminar on this project at FAS next spring, so tune in for the results!
such as the introduction of advanced sewage treatment facilities. By contrast, environments subject to diffuse inputs of nutrients, such as agricultural or suburban runoff, are more difficult to manage because sources are harder to control. Another complication in many lakes, such as Lake Okeechobee, comes from the accumulation of nutrient-rich sediments over long periods of time. These sediments represent a pool of nutrients that can sustain algal blooms for extended periods even after sources of external nutrients are eliminated. Developing a management plan to control nutrient availability requires careful consideration of all of these issues, as well as a clear vision of the desired and realistically attainable goals.

Besides long-term management of nutrient inputs as a means of limiting algal blooms, individual blooms can be treated ex-post-facto with chemical algicides, such as copper sulfate. Herbicides are widely used in Florida to control aquatic weeds like Hydrilla, but the use of algicides to control blooms is less common and generally limited to small water bodies due, in large part, to high costs. There are also potentially negative consequences from the use of chemicals to control blooms. Mass mortality of algae resulting from treatment can result in a rapid increase in bacteria feeding on and decomposing the dead algae. These bacteria can use oxygen and release ammonia at levels that pose threats to animals. Decomposition of algae also leads to release of nutrients that can stimulate subsequent blooms unless chemical treatments are repeated on a regular basis. In the case of toxic algae blooms, chemical treatments also can cause a sudden release of toxins from the algal cells into the water column, which may cause undesirable changes.

4. What are scientists in the Department of Fisheries and Aquatic Sciences doing about toxic cyanobacterial blooms?

One of the central goals of the Department of Fisheries and Aquatic Sciences is to provide objective information that citizens and resource managers can use to make informed decisions about water resources and to develop effective programs that protect the integrity of aquatic environments and human health. For 20 years, we have studied the occurrence, causes and control of cyanobacterial blooms in Florida’s aquatic systems, including Lake Okeechobee, the St. Lucie River and Estuary, the St. Johns River, the Kissimmee River, Florida Bay and numerous inland lakes. Our work documents links between bloom formation and various environmental factors, including water column stability, water residence time, dissolved nutrient concentrations, and meteorological conditions. At the present time, we are working with scientists and managers from State and Federal agencies to establish a statewide program to assess the distribution and frequency of non-toxic and toxic cyanobacterial blooms and the relationship between these outbreaks and variations in weather and land use. We also contribute to an understanding of how toxins affect fish, shellfish, aquatic plants, and other components and processes in aquatic ecosystems. Unanswered questions include: How many blooms in Florida’s waters are toxic? Are these blooms more or less toxic than those in other regions of the world? What are the ecological effects of toxins, including both direct effects and indirect effects that might occur if toxins change predator-prey or competitive interactions in aquatic food webs? How high are toxin levels in different species of fish that are regularly caught by recreational and commercial fishers? The broad range of expertise available within the Department of Fisheries and Aquatic Sciences, in combination with the substantial physical and intellectual resources in IFAS and the University of Florida community, provide unique opportunities for meaningful, state-of-the-art research to address these important questions.

“We also have to be careful with what we take with us when we select for certain traits,” Wallat said. “We don’t want to produce a fish that is susceptible to disease or produces poor muscle quality.”

Researchers are in their second year of the four-year study, selecting the top 10 percent group for growth per generation and using that group as the basis for the next breeding generation.

Written Friday, September 09, 2005


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In one aspect of the project, researchers are crossbreeding the North Carolina strain with the Ohio strain, banking that genetics and geography will produce a high-performance fish.

“Sometimes geographically related species, such as Ohio and Pennsylvania, are close genetically, which may not be what we always want,” Wallat said. “It may be that the least-related is what performs the best.”

Ohio strains have so far outperformed Pennsylvania and New York strains of yellow perch.

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