

The effects of cyanobacteria on animal and public health

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Seminar objectives

- To demonstrate the breadth and diversity of issues from cyanobacteria/cyanotoxins in FL
- To identify the challenges in field investigations and diagnostics
- To discuss emerging issues

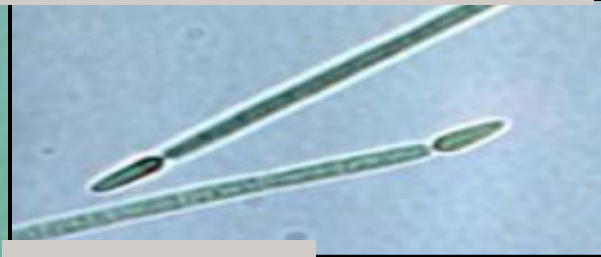


Florida's diverse cyanobacteria blooms



Cyanobacteria and cyanotoxins in Florida

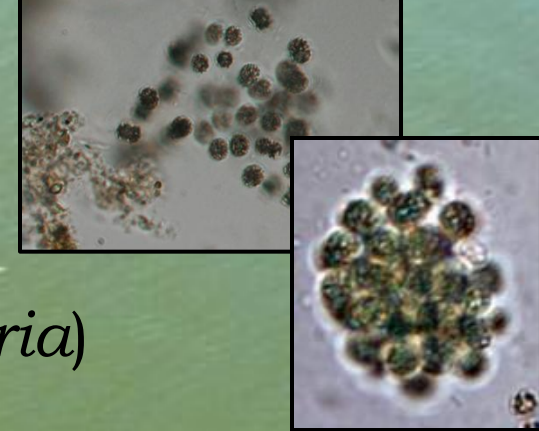
Cylindrospermopsins



Freshwater

- *Microcystis*
- *Cylindrospermopsis*
- *Anabaena*
- *Aphanizomenon*
- *Planktothrix (Oscillatoria)*
- *Lyngbya wollei*
- Stigonematales

Microcystins



Saxitoxins



Lyngbyatoxins

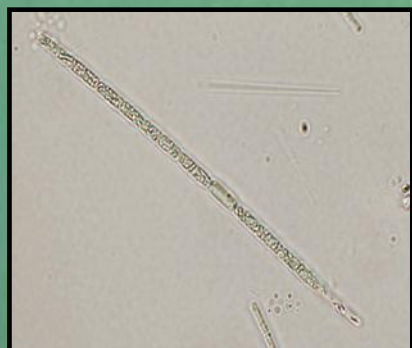
Marine

- *Trichodesmium*
- *Lyngbya* spp.
- *Geitlerinema*
- *Leptolyngbya*
- *Synechococcus*

Anatoxins



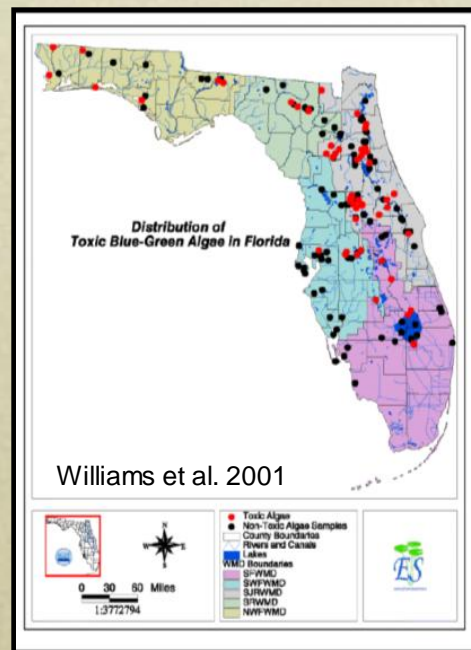
Debromoaplysiatoxin



> 40 potentially harmful or toxic species

Freshwater cyanobacteria in Florida

- Cause significant economic and ecological impacts (e.g. St Johns, Caloosahatchee rivers, Lake Munson, private ponds)
- Risk for animal and public health
- Contaminate drinking water sources
- Toxicoses (fish, wildlife, livestock, pets)
- Recreational exposures
- Chronic health effects (tumor promoters)
- Ecosystem disruption (anoxia/hypoxia [fish kills], light attenuation [SAV])
- Cyanotoxins in food webs



Freshwater cyanotoxins in Florida

- Neurotoxins (saxitoxins, anatoxins)
- Hepatotoxins (microcystins, cylindrospermopsins)
- Dermatotoxins (lyngbyatoxins, debromoaplysiatoxin)
- Bioactive compounds (e.g. LPS, hemolysins)
- Different species can produce same toxins
 - e.g. saxitoxins (*Lyngbya wollei*, *Aphanizomenon* spp., *Anabaena*, *Cylindrospermopsis*)
- Individual species can produce diverse toxins
 - e.g. *Cylindrospermopsis raciborskii* (cylindrospermopsin, saxitoxin)
- Exposure by ingestion, inhalation, dermal



Microcystins (MCYST)

- Common in freshwater (*Microcystis*, *Anabaena*)
- “Paint-green” discoloration (*Microcystis* blooms)
- Primary exposure by direct ingestion
- Hepatotoxic and tumor promoters
- Affect invertebrates, fish, birds, amphibians, reptiles, mammals
- Rapid assays (ELISA, PPIA) and confirmation (HPLC, LC/MS)
- Need to assess health risks from chronic and low level exposure
 - Temporary food chain transfer

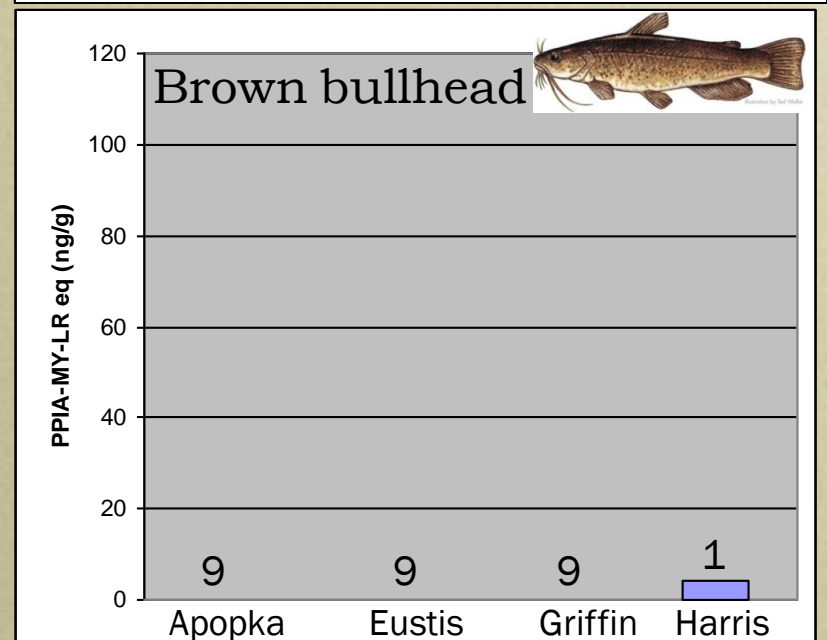
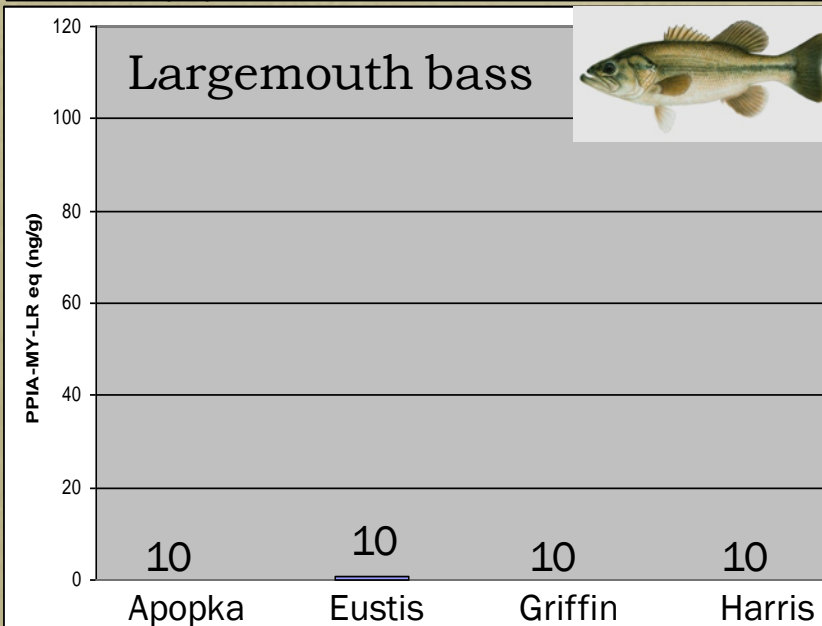
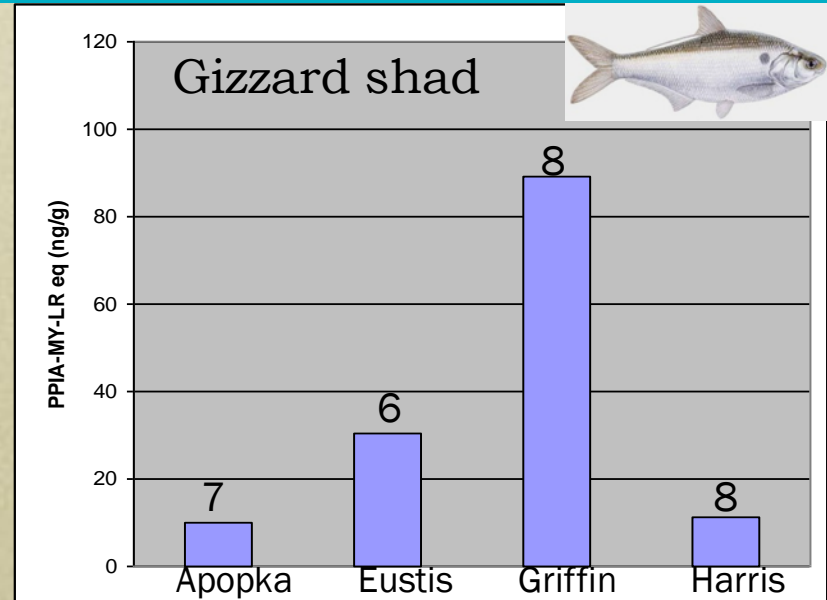
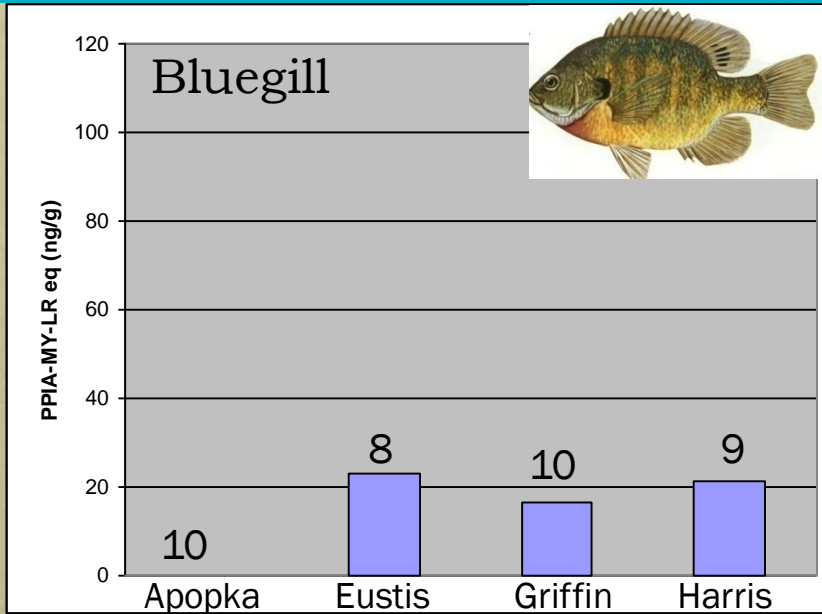


Microcystins (MCYST) in fish

- Four lake survey, Lake County
- Bi-seasonal
- Four fish species
- Different trophic levels
- Microcystins in GI tract, liver
- Low concentrations-planktivores/
omnivores (gizzard shad, bluegill)
- Negligible or below detect-piscivores/benthic fish
(largemouth bass, brown bullhead)
- Transient in relation to bloom
 - Subtle hepatic pathology



Microcystins (MCYST) in fish



Mean microcystin concentrations in livers – Aug 2006 (FWC, unpub. data)

Cylindrospermopsis raciborskii (CYN, STX)

- Sub-tropical” species
- Detected in FL in mid-1990s
- Expanding distribution
- Associated with several animal mortality events
 - 1998–2003, alligator die-off, Lake Griffin
 - thiamine deficiency [Ross et al.], cyanotoxins?
 - 2007, mallard mortalities, Lake Munroe
 - low level cyanotoxins in liver
 - co-associated with botulism
- Multi-factorial
- Challenge to confirm cyanotoxin etiology



Saxitoxins (STXs)

- Neurotoxins (hydrophilic)
- Diverse species (*Lyngbya wollei*, *Anabaena*, *Aphanizomenon* spp., *Cylindrospermopsis*)
- STXs > 20 congeners, profiles “fingerprint” of source
- dcGTX-2,3/dcSTX* in manatee stomach content
- ?Source *L. wollei* mats on SAV in freshwater
- *L. wollei* saxitoxin profile (dcGTX-2,3/dcSTX)
(Foss et al. 2012)
- Low level STXs in SJR blue crabs*
(source unknown)



*Flewelling et al. FWRI/FWC (unpub. data)



Mixed cyanobacteria blooms/toxins

- Common in freshwater, seasonal
- Bloom succession by dominant species
- Challenges to interpret multiple toxins
- e.g. SJR 2010 fish kill (*Aphanizomenon* dominant)
- Chronic fish die off (low concentrations of microcystin, saxitoxin, cylindrospermopsin)
- Likely role for other bioactive compounds
- Cyanobacteriolytic bacteria



Red drum eye - congestion



Red drum liver - congestion



Emerging issues and challenges

- Chronic exposure/role in mortality events
- Expansion and drivers of toxic species
- Synergistic effects > multiple toxin exposures
- Accurate detection methods for known toxins
- Risk assessment of “new” toxins/disease syndromes (AVM/BMAA)
- Toxins as tumor promoters (MCYST)
- Transport of cyanotoxins into marine systems
- ?Dermatopathologies (debromoaplysiatoxins)
- Role of cyanoHABs as pathogen vectors
- Role of cyanobacteriolytic bacteria in disease



Avian vacuolar myelinopathy (AVM)



- Lethal neurological disease (SE USA)
- Epiphytic cyanobacterium (Stigonematales) vectored via vegetation (e. g. *Hydrilla*)
- Neurotoxin > coots > bald eagles
- AVM brain lesions, affects flight, behavior > death
- Statewide surveillance (one positive [PCR] lake [N=47])
 - AVM bird surveillance
 - Dr. Wilde (SC) monitoring in Lake Toho



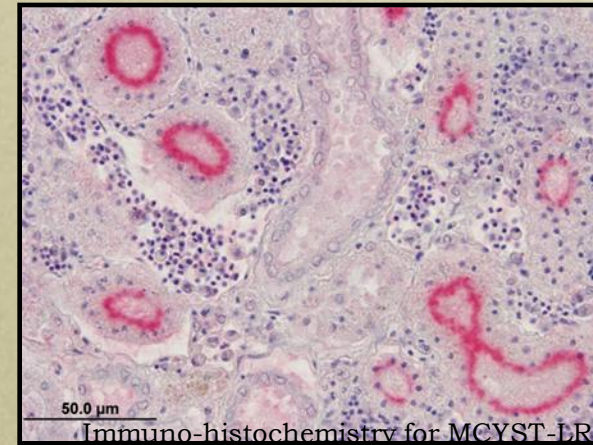
Beta-N-methylamino-L-alanine (BMAA)

- Reported from diverse cyanobacteria
- Freshwater and marine habitats
- Hydrophilic neurotoxin
- Interacts with glutamate receptors
- Implicated in neurodegenerative diseases
 - Alzheimer's, Amyotrophic Lateral Sclerosis
- Putative presence in invertebrates and fish (SFL)
(Brand et al. 2010)
- Significant scientific debate regarding accurate chemical identification and risk in aquatic systems
 - Requires interlaboratory validation
- Consensus peer review – no health threat?



Diagnostic challenges

- Microcystin (e.g. MC-LR) is detected in tissues by ELISA/PPIA, confirmed by HPLC/LCMS
- Microcystin binds covalently to protein phosphatases
- Challenge for tissue extraction (traditional analyses ~ underestimates)
- > 80 microcystin congeners (maybe environmentally relevant, not all monitored)
- Microcystin not only hepatotoxic
- Few analytical laboratories available
- Budgetary constraints for routine monitoring and investigative diagnostics



State agency resources

- FWC - Wildlife alert hotline: 1-888-404-3922
Fish kill hotline: 1-800-636-0511

<http://research.myfwc.com/fishkill/submit.asp>

HAB report status: 1-866-9399

- FDOH - Aquatic toxins hot line: 1-888-232-8635

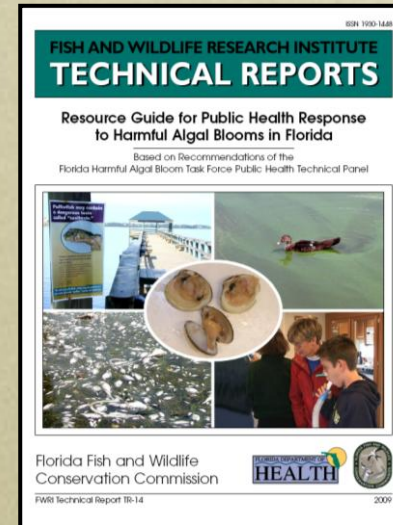
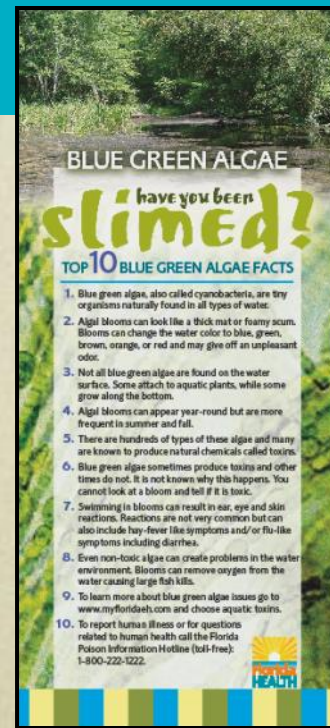
<http://www.doh.state.fl.us/Environment/medicine/aquatic/>

- FDACS - 1-800-435-7352

- FDEP - WQ monitoring/event response

<http://www.dep.state.fl.us/labs/biology/hab/index.htm>

- WMDs - WQ monitoring/event response



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