HABs in Louisiana:

**Common HAB species**
Harmful/toxic phytoplankton have been the subject of regional interest in Louisiana for many decades. Studies of Louisiana coastal and estuarine waters document the occurrence of the toxic diatom *Pseudo-nitzschia* spp., raphidophytes, several species of toxic dinoflagellates including *Alexandrium monilatum*, *Gymnodinium* spp., *Karenia* spp., *Lingulodinium polyedrum*, *Prorocentrum* spp., *Heterocapsa*, and *Dinophysis* spp., brown-tide alga *Aureoumbra*, and toxic cyanobacteria populations including *Anabaena cf. circinalis*, other *Anabaena* spp.(up to 6 additional species), *Microcystis* spp., *Cylindrospermopsis raciborskii*, *Raphidiopsis curvata*, and *Anabaeonopsis cf. elenkenii*. Several of the species mentioned above are often observed in bloom quantities.

**HAB species of current concern**
Many of these species have a potential to create public health risks, cause mortalities of marine organisms, or alter the capacity of coastal ecosystems to support living resources. Among these HAB species, *Pseudo-nitzschia* spp. and its toxin domoic acid (DA) in coastal waters and toxic cyanobacteria in estuaries are the most immediate concerns.

*Pseudo-nitzschia* is present much of the year and occurs in high numbers (>10^6 cells/L) in inshore and offshore water bodies of Louisiana and sometimes in the estuaries over oyster reefs (Dortch et al. 1997, Parsons et al. 1998, 1999, Bargu et al. in prep). Associated toxin production has been documented in the field (Parson et al. 1999, Bargu et al. in prep). Ongoing research suggests that *Pseudo-nitzschia* is most abundant, and consequently water contains the highest toxin levels, usually in early spring, when riverine input increases and brings excess of available nutrients (Bargu et al. in prep). To date, maximum DA was found to be about 13 µg DA/L from April 2007 and highest cellular DA was found to be 19 pg DA/cell from April 2008, when cell numbers in both cases were exceeding 10^6 cells/L (Bargu et al. in prep). These toxin values are not far from what has been previously found in California where animal mortalities were observed.
Cyanobacteria are also commonly found within the fresh and brackish waters of the many estuary systems in Louisiana, including the species of the colonial cyanobacteria *Anabaena* cf. *circinalis*, other *Anabaena* spp., *Microcystis* spp., *Cylindrospermopsis raciborskii*, *Raphidiopsis curvata*, and *Anabaenopsis* cf. *elenkenii*, which are associated with either or both hepatotoxin or neurotoxin production or water discoloration. Nutrient additions in bioassay microcosms with water from this area also stimulated the growth of these cyanobacteria (Ren et al., 2008). A recent study (Garcia et al. in review) demonstrated that *Cylindrospermopsis*, *Microcystis*, and *Anabaena* spp. often reached bloom concentrations over an 8 month study period in Lac des Allemandes, located within the Barataria estuary system of Louisiana, an area which serves as a critical nursery ground for blue crab.

The ecology of these specific groups are poorly understood – specifically which species are toxic and what controls their toxicity in a large river plume, thus complicating efforts to control outbreaks or to determine to what extent their toxin can be transferred through the food web. The major importance of their high cell numbers is of course due to the potential threat of contamination within the pelagic and benthic system.

Despite the presence of abundant and toxic *Pseudo-nitzschia*, there have been no known confirmed incidents of Domoic Acid Poisoning (DAP) reported from the northern Gulf of Mexico. However, several filter feeders such as oysters and menhaden have shown to be potential vectors of DA to higher trophic levels, including humans (Thessen et al. 2001, Del Rio et al. in prep.). Recently, both in 2007 and 2009, several dolphin strandings have been reported on the Texas/Louisiana border and Mississippi respectively. In both cases, dense blooms of *Pseudo-nitzschia* in the northern Gulf of Mexico region were identified, and initial biotoxin results were positive for domoic acid (Biotoxin Lab report, South Carolina).

Recreational activities such as swimming can result in exposure to contaminated water, as can being on the water in recreational or commercial pursuit of fish, crustaceans and shellfish. Toxic cyanobacteria blooms are frequent in Louisiana estuaries and public health risks need to be closely evaluated. Microcystins have been found in blue crabs collected from Lac des Allemands (Garcia et al. in review). The highest concentration of microcystins occurring in crab tissue directly corresponded with the highest abundance of *Microcystis* cells found in surface waters, which were close to or exceeding the WHO-TDI guidelines for human consumption.

**Future HAB concerns**

**Ciguatera Fish Poisoning (CFP)**

In a recent study conducted off the northeast coast of Texas, Villareal et al. (2007) found *Gambierdiscus* on 6 oil platforms and found ciguatoxins in nearby fish. The presence of *Gambierdiscus* on platforms and the immense popularity of platforms as fishing areas increase the likelihood of ciguatoxic fish in the Gulf of Mexico. In fact, two people reported ciguatera-like symptoms after eating barracuda and snapper fished from a Texas oil rig (Villareal et al. 2006). Each platform in the Gulf of Mexico seasonally serves as critical habitat for up to 20,000 commercially, recreationally and ecologically important fishes (Dauterive 2000). As of 2006, the Louisiana artificial reef program has created over 83 artificial reef sites using over 120 decommissioned oil and gas platforms making Louisiana home to the world’s largest artificial reef complex (Kaiser 2006). Prior to placement of oil and gas platforms, relatively little hard substrate (e.g., coral reefs) was available in the Gulf of Mexico. Recent work, however, has revealed the geographic expansion of reef associated organisms including the toxic algae, *Gambierdiscus*, to oil and gas platforms in the northeastern Gulf of Mexico. Prior to platforms, *Gambierdiscus* was restricted to more tropical areas. Through human-induced alterations such as global warming and habitat modifications (i.e. platforms in Gulf of Mexico), it is likely that *Gambierdiscus* has expanded its distribution to include oil and gas platforms throughout the Gulf of Mexico. The expansion of
*Gambierdiscus* to Louisiana oil and gas platforms could be detrimental to the fishing industry. The use of oil and gas platforms as fisheries enhancements may increase reported cases of CFP in Louisiana and throughout the world through export of fish and the impact to commercial and recreation fisheries could be substantial.

**Diarrhetic Shellfish Poisoning (DSP).**

*Dinophysis* spp. are commonly found within the phytoplankton community in Louisiana coastal waters, numbers reaching $2.7 \times 10^5$ cells/L. There is no toxin confirmation of these species in the area but needs to be monitored more carefully since their toxin (okadaic acid) may accumulate in the tissues of several intermediate organisms over time and reach to higher trophic levels, including humans.

**Louisiana HAB research and monitoring activities in last two years:**

**Ongoing activities**

Louisiana HAB research, including the species of cyanobacteria and one of their toxins, microcystin, and *Pseudo-nitzshia* and its toxin domoic acid, are currently being undertaken mainly by Louisiana Universities Marine Consortium and Bargu Lab at Louisiana State University, Department of Oceanography and Coastal Studies. Specific research activities as follows:

*Louisiana Universities Marine Consortium (LUMCON) Phytoplankton Group*  
(Drs. Nancy Rabalais and Geoff Sinclair, Wendy Morrison)

Phytoplankton community composition studies over a range of habitats have been ongoing in coastal waters since 1989 by LUMCON researchers. Dr. Quay Dortch established the HAB research and monitoring program at LUMCON; upon her departure Dr. Nancy Rabalais took over her programs and research group, and they are continuing to collect data in the same areas.

The distribution of samples extends from the Mississippi River delta to the middle Texas coast, from near shore to as far as 100 km offshore. Monthly phytoplankton samples from transects off Terrebonne and Atchafalaya Bays, and annual shelf-wide mid-summer transects are collected. In addition to these marine samples, the LUMCON Phytoplankton Group has been participating in a monthly transect of 37 stations along the axis of the Barataria Basin (a highly eutrophic system with a wide range of salinities and residence times) since January 1994. The transect spans from a freshwater stream entering Lac des Allemands on the north through an estuarine tidal pass near Grand Isle, Louisiana on the south. Five stations per month are counted for HABs. The result of this extensive sampling has been the collection of a variety of phytoplankton species from many diverse groups. An in-house species list of those taxa encountered over the years was created and is still being maintained; many of the species on that list have been photographed and archived with collection data in the course of developing the taxonomic expertise of the LUMCON Phytoplankton Group. In addition to routine phytoplankton monitoring efforts, the Phytoplankton Group also provides assistance with taxonomic identification and enumeration on samples of suspected harmful algal blooms collected by state and federal water quality officials, or from the general public.

In 2005 the Phytoplankton Group received funding from the EPA Gulf of Mexico Program to produce a web- and cd-based taxonomic “Guide to Phytoplankton from Louisiana Estuarine and Coastal Waters,” including taxa that have been shown in the literature to be harmful or noxious. This funding will help make available the accumulated taxonomic knowledge of the LUMCON Phytoplankton Group and should directly facilitate the transfer of biological information to other researchers, the educational community, and resource managers charged with protecting water quality. The Guide will be a
searchable, annotated pictorial atlas of phytoplankton species found in the Barataria, Terrebonne, and Pontchartrain estuaries and coastal Louisiana offshore waters, and will include for each species, photographs taken with different light and stain techniques, distinguishing identification characteristics, taxonomic classification, size ranges, distribution, references to useful literature, and comments as to toxicity or harmful effects. The Guide is scheduled to be completed in June 2009 and will be published on a website maintained at LUMCON, and CD ROMs to be distributed upon request.

In 2006, the Phytoplankton Group received funding, also from the EPA Gulf of Mexico Program, for a project to study HAB species and the presence/absence of associated toxins in three large fresh to brackish water lakes (Lac des Allemands, Lake Cataouatche and Lake Salvador) in the upper portion of the Barataria Basin. This environment supports a variety of HAB species due to high nutrient inputs, and cyanobacterial blooms occur on a regular basis, including species that have been toxic in Lake Pontchartrain (Anabaena cf. circinalis) or elsewhere (Microcystis, Cylindrospermopsis raciborskii, Raphidiopsis curvata). Of the few analyses done before this project began, microcystins were documented in water from Lac des Allemand, the most eutrophic of the three lakes. The Davis Pond Diversion is a controlled diversion of Mississippi River water into the upper end of Lake Cataouatche that began in late 2003. Although the diversion is not yet fully operational as originally designed, the limited outflows have affected the salinity regimes in Lakes Cataouatche and Salvador, and salinity is a major environmental factor controlling blooms of cyanobacterial HABs. Increased nutrient loads also stimulate phytoplankton biomass and increase cyanobacteria, including potential toxin-producers. The project goal is to document what HAB species are present in field water samples that also test positive for certain toxins, to isolate and grow in the lab monocultures of the ambient HABs and analyze those samples for toxins, all in an effort to link species and toxins. Toxin analyses will also be conducted on consumers of cyanobacteria (such as fish, crustaceans and shellfish) to identify food resources that could cause a potential human health problem because of the ingestion or accumulation of the toxins by the seafood (Both water and tissue toxin analyses will be conducted by Bargu Lab at Louisiana State University).

LUMCON’s Environmental Monitoring System (part of the GCOOS-RA) collects and archives real-time meteorological and hydrographic data to provide a broad community of scientists, educators, students, and the public with quality-controlled environmental data from Louisiana’s Gulf Coast. Six remote monitoring stations are located along the southeastern Louisiana coast in Lake Pontchartrain, the Mississippi River at New Orleans, Southwest Pass, Cocodrie, Terrebonne Bay, and Bay Tambour. The data from these stations are freely available in real-time on the World Wide Web http://weather.lumcon.edu. In addition, there are two integrated ocean observing systems with a full complement of meteorological, wave, current, and hydrographic data (including T, S, DO, turb, fluor) at two locations--offshore Terrebonne Bay in 20 m water depth and offshore Caminada Pass in 15 m water depth. These stations are a collaboration of the Rabalais et al. NGOMEX06 program and Greg Stone's WAVCIS network (http://wavcis.csi.lsu.edu).

Louisiana State University, Department of Oceanography and Coastal Studies- Phytoplankton Ecology and HAB Lab
(Drs. Sibel Bargu and Kari Galvan, Ross Del Rio, Ana Cristina Garcia and Jessica Czubakowski)

Dr. Sibel Bargu has expertise in phytoplankton ecology, HABs and food web interactions. Currently, her lab studies the trends in phytoplankton populations to address the causes of the apparent increase in harmful algae. Dr. Bargu’s regional HAB related main research efforts are to understand the physical and chemical conditions that initiate and promote major algal blooms, including the toxic ones; to measure their species-specific growth response, cell abundance and toxin productions under changing nutrient conditions; and to examine the extent to which phytoplankton toxins (possibly from increasing HAB
events) are permeating aquatic food webs. Quick toxin measurements became feasible in Louisiana with Bargu’s trained lab members and her lab facilities at LSU which contain all the necessary equipment including a plate reader for ELISA assays.

In 2007, Dr. Bargu received funding from the Louisiana Board of Regents to monitor the distribution, abundance and toxicity of *Pseudo-nitzschia* in Louisiana coastal waters. This is the only existing study in Louisiana that focuses on the toxicity of this diatom. This funding will allow her to continue *Pseudo-nitzschia* monitoring until 2010. In 2008, she and one of her students, Ana Cristina Garcia (and et al.) studied blue crab contamination from cyanobacteria toxin microcystins and evaluated the potential risk of microcystins to blue crab (*Callinectes sapidus*) fisheries and human health in Barataria estuary (Garcia et al. in review). Studies in method development for efficient cyanotoxin extraction in tissue samples are still ongoing. In the same year, she participated to an NSF funded research to study the effects of a large freshwater diversion on physical, chemical and biological characteristics of a shallow, estuarine lake, Lake Pontchartrain. She also received several NOAA funding to support graduate student research and additional support for event responses. Current student/postdoc projects are:

2. “The role of nutrient loaded freshwater on seasonal phytoplankton successions and phycotoxin production in Breton Sound, Louisiana” (Thesis, Jessica Czubakowski)
4. “The effects of Hurricane Gustav and Ike on sediment grain size, nutrients, Chlorophyll *a* and algal species composition in a Louisiana, shallow coastal bay” (Dr. Galvan)

Since 2007, Dr. Bargu is offering graduate level “Harmful Algal Blooms (HABs)” course at LSU.

The LSU Coastal Studies Institute also maintains five monitoring stations in bays and nearshore environments of southeast and south-central Louisiana which may be useful to HAB monitoring. Dr. Nan Walker and her graduate student, Padmanava Dash, conducted extensive bi-weekly and weekly field trips in the years 2006-2007 to obtain a database of photosynthetic pigment concentrations and phytoplankton composition which are being used in tandem with measurements from the Ocean Color Monitor (OCM) sensor to quantify blooms from space. Development of algorithms for chlorophyll *a*, cyanobacteria (using Phycocyanin pigment), *Anabaena* (using Echinonone pigment) and *Microcystis* sp. (using Myxoxanthophyll pigment concentrations) is underway.

*Previously Nicholls State University, currently University of New Orleans*

Drs. Thomas Soniat and Sammy Ray (Texas A&M University at Galveston) maintain Oyster Sentinel ([www.oystersentinel.org](http://www.oystersentinel.org)), a gulf-wide collaboration which uses oysters as bio-indicators of estuarine health. The web site is offered as one of many that will disseminate information concerning HABs in the Gulf of Mexico. Oyster Sentinel assisted in the establishment of the Bay Tambour monitoring station which is operated and maintained by LUMCON. The station is adjacent to an oyster reef that has been regularly sampled for more than a decade. Cooperatively with the Dortch lab a long-term data set of chlorophyll *a* and phytoplankton-species composition from water samples collected above oyster reefs was generated, and studies were conducted on the ability of oysters to ingest *Pseudo-nitzschia*. 
The LDHH is the lead agency responsible for assuring the microbiological quality of shellfish-growing waters in Louisiana. Anthony Roussell used to direct the program and monitor Karenia brevis according to Interstate Shellfish Sanitation Conference (ISSC) guidelines. LDHH has an in-house laboratory for the identification and enumeration of K. brevis only. They cooperate with the Louisiana Department of Wildlife and Fisheries, which manages the oyster fishery and alert them to HAB events, and the Louisiana Universities Marine Consortium. Currently, Gordon LeBlanc is the new director of this program and their current monitoring effort focuses mainly on coliform and enterococci bacteria, not much on K. brevis.

Pending activities

Dr. Bargu and her colleagues Dr. Hugh McIntyre from DISL and Dr. Greg Doucette from Marine Biotoxins Program, NOAA/National Ocean Service, Charleston, SC are expecting to get additional funding to continue to study the abundance and toxicity of Pseudo-nitzschia spp. in the Northern Gulf of Mexico. One of the main efforts in this project will be to develop the species specific probes for isolated Pseudo-nitzschia species from GOM. Dr. Bargu’s lab is also expecting to get additional funding to study food web effects of toxic cyanobacteria in Louisiana estuaries.

Perceived gaps in Louisiana HABs research and monitoring:

Ongoing efforts to address the distribution of HAB toxins and toxin-producing species in Louisiana estuaries, effects of co-occurring toxins on human health, and the presence of HAB toxins in sediments in current studies are limited. Additionally, food web effects of algal toxins, identification of vector species, and effects of anthropogenic disturbances on estuarine plankton communities are not widely studied. Although presence of Pseudo-nitzschia and toxic cyanobacteria have been well documented in Louisiana’s coastal and estuarine waters, limited studies on its ecology make it imperative to understand how toxins are vectored through Louisiana’s aquatic food webs.

One reason for the limited HAB studies in Louisiana is the lack of funding for continuous HAB monitoring, which limits the sampling opportunities to once a month, and the lack of state agencies’ involvement in monitoring efforts. The HAB monitoring team in Louisiana is very small, limited to LUMCON’s phytoplankton group and Dr. Bargu’s HAB Lab at LSU. There is no mechanism in place to organize a network to increase the interaction with state agencies, which would lead to more complete monitoring of HABs in Louisiana.

One of the other major issues is not having the capability of doing quantitative monitoring for toxic Pseudo-nitzschia. Accurate identification of similar species of Pseudo-nitzschia is difficult. Since not all species in the genus are toxic, identification of species is important in order to mitigate its harmful effects. Currently, identification of these species in Gulf of Mexico is based on morphological differences seen through the use of electron microscopy (EM). However, this technique is time consuming, expensive and requires a lot of expertise to distinguish pore numbers, sizes, presence/absence of central nodulus etc. The development of the Whole cell hybridization technique was a great improvement for identifying the toxic species quickly and quantifying them at the same time. However, probes are not available for all species of Pseudo-nitzschia, and, due to strain variability, are not applicable to all locations where Pseudo-nitzschia is found.

Other specific gaps in LA HAB research and monitoring are listed below:
• Data analysis of temporal trends in HAB occurrences
• HAB and toxin correlations with environmental variables
• Identification of dinoflagellate species
• Determining the persistence of toxins in ecosystem (once bloom terminates is there residual toxins in system?)
• Potentially unnoticed HABs and animal strandings due to lack of recreational beach use

Need for additional HABs-related tools/services to support Louisiana HAB activities:

A consistently funded state-wide phycotoxin testing/monitoring service is needed for Louisiana to monitor specifically *Pseudo-nitzschia* and cyanobacteria abundances in coastal and estuarine waters. To achieve this, more collaboration between government and academia and increased dissemination of knowledge to the general public (outreach) on these issues are desperately needed.

References:


Villareal TA, Hanson S, Qualia S, Jester ELE, Granade HR, Dickey RW. 2007. Petroleum production platforms as sites for the expansion of ciguatera in the northwestern Gulf of Mexico. Harmful Algae 6:253-259