EPA Region 4 Harmful Algal Bloom
Southeastern Regional Workshop Agenda

Day 3 – Wednesday, May 16, 2018

Recording: http://epawebconferencing.acms.com/p56t6a35ly8/

Marine and Coastal HABs		
Time	**Presentation Title**	**Speaker**
8:00 – 8:10 am	Welcome and Introductions	Region 4, EPA
8:10 – 8:40 am	Marine HABs and their Effects on Fish and Wildlife	Jan Landsberg, FFWC
8:40 – 9:00 am	Phytoplankton Monitoring Program along the Alabama Gulf Coast	Drew Sheehan, ADPH
9:00 – 9:20 am	Public Health Response to Marine HABs in Florida	Andrew Reich, FDOH
9:20 – 9:40 am	Mississippi Marine Biotoxin Contingency Plan	Kristina Broussard, MDMR
9:40 – 10:00 am	Q&A and Open Discussion	EPA
10:00 - 10:10 am	Break	
10:10 - 10:40 am	Applications of Satellite Data to Monitoring and Assessment of Harmful Algal Blooms	Rick Stumpf, NOAA
10:40 – 11:10 pm	Crossing State Lines: Gulf of Mexico Alliance (GOMA) Efforts to Enhance Harmful Bloom Monitoring and Prediction	Kate Hubbard, FFWCC
11:10 – 11:40 am	Strategies for Mitigating Adverse Effects of HABs	Richard Pierce, Mote Marine Laboratory
11:40 – 12:00 pm	Q&A and Open Discussion	EPA
12:00 pm	Closing Remarks and Adjourn	EPA

EPA Region 4 Harmful Algal Bloom

Southeastern Regional Workshop Agenda

Biographies of Presenters

Dr. Jan Landsberg is a Research Scientist with the Florida Fish and Wildlife Conservation Commission (FWC) at the Fish and Wildlife Research Institute, St. Petersburg, Florida. She has been with the agency since 1989. At FWC, Dr. Landsberg has investigated disease and mortality events affecting Florida's aquatic animals, provided health support to FWC's aquaculture and stock enhancement operations, and conducted research on aquatic animal health and the effects of harmful algal blooms (HABs) on aquatic organisms, with potential implications for public health. She has authored or co-authored ~ 80 peer-reviewed scientific papers or book chapters. From 2002–2006, she was the agency lead on the investigation of the pufferfish poisoning incidents in the Indian River Lagoon and coordinated a multiagency team that identified saxitoxins in *Pyrodinium bahamense* as the toxin source in the USA for the first time. From 2005–2008, she served on the U.S. National HAB Committee and from 2008–2014 was a member of NOAA's National Working Group on Unusual Marine Mammal Mortality Events. She is currently assisting with the multiagency investigation of the widescale coral disease and mortality event in the Florida Keys and Southeast Florida.
Email: Jan.Landsberg@MyFWC.com; Phone: 727-502-4880

Mr. Drew Sheehan is a Senior Microbiologist for the Alabama Department of Public Health, Bureau of Clinical Laboratories, Mobile Division Lab. He began his career with ADPH in 2010. He is the primary analyst in the labs Environmental Section, responsible for oyster growing water testing, oyster meat testing, harmful algal bloom identification/enumeration, Beach water testing, and Drinking water testing. Mr. Sheehan is a significant contributor to the Bureau's initiative to achieve ISO 17025 accreditation for analysis of crab meat product available in Alabama. Mr. Sheehan has worked with Alabama's HAB monitoring program for 7 years. Drew received his Bachelor of Science Degree in Microbiology from Auburn University.
Email: drew.sheehan@adph.state.al.us; Phone: 251-344-6049

Mr. Andrew Reich is the scientific advisor to the Chief of the Bureau of Environmental Health at Florida Department of Health. He has over 25 years of experience in public health addressing issues such as water quality, fish advisories, hazardous waste investigations, toxicology consultations, environmental contamination and disease outbreaks. For over 10 years Mr. Reich has lead the Department's effort to address adverse health impacts from exposures to toxic algal blooms in fresh water and marine environments. His efforts have led to an integrated and collaborative approach to environmental health response in Florida with federal, state, and local partners including NOAA, CDC, Army Corps of Engineers and the US Environmental Protection Agency. Mr. Reich has a Master's of Science degree in Public Health from the University of Alabama in Birmingham as well as a Master's in Medical Science from Emory University in Atlanta, Georgia with a concentration in Intensive Care Medicine.
Email: andy.reich@flhealth.gov; Phone: 813-307-8015 Ext.5961

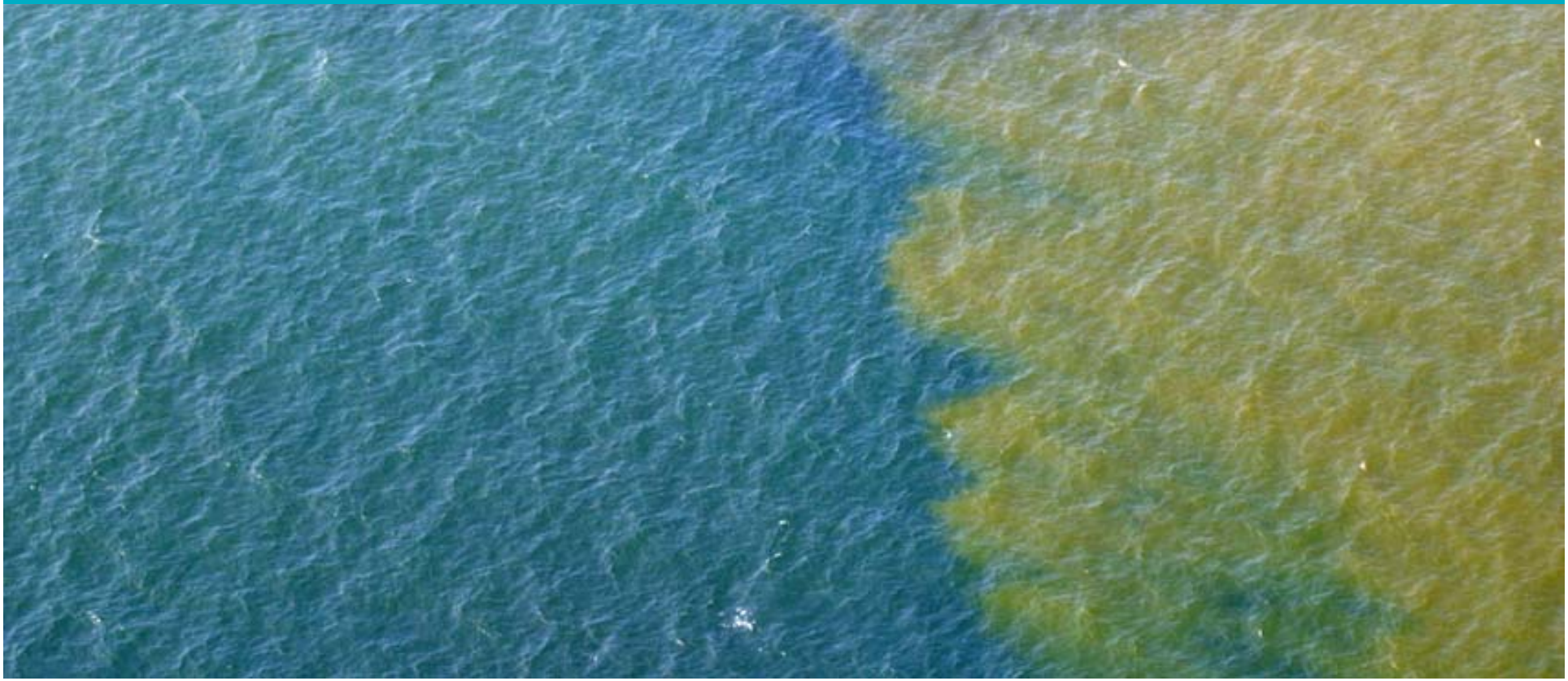
Ms. Kristina Broussard is the Biological Program Coordinator and Lab Director for the Mississippi Department of Marine Resources, Marine Fisheries, Shellfish Bureau. She is the lead scientist for monitoring and identifying marine biotoxins and has been the supervisor of the Marine Biotoxin Program for the State of Mississippi since April, 2009. This position includes monitoring MS oyster reefs for harmful algal blooms and coordinating with the Food and Drug Administration to ensure compliance with governmental guidelines. During her time with the MDMR, Ms. Broussard has authored two books titled: 'How to Start a Seafood Business in South Mississippi' and 'Oystermen's Guide to Mississippi Gulf Coast Oyster Reefs'. Ms. Broussard has been a member of the Gulf of Mexico Alliance since 2009.
Email: kristina.broussard@dmr.ms.gov; Phone: 228-523-4067

Dr. Richard Stumpf leads NOAA's efforts to monitor and forecast harmful algal blooms, especially solving how to translate research into operations. He has over thirty years of experience in coastal oceanography, and he has investigated eutrophication, water quality, and habitat along most of the U.S. coast from Maine to Hawaii. He led the development of both the Gulf of Mexico and Lake Erie Harmful Algal Bloom Forecast Systems, and was instrumental in starting NOAA's CoastWatch program, the first program to routinely deliver oceanographic satellite imagery to coastal managers. He advises various state, national, and international agencies on monitoring strategies for algal blooms. Prior to working at the National Ocean Service, he was a research scientist with the U.S. Geological Survey in their Coastal and Marine Program in Florida. He has a B.A. degree in the Environmental Sciences from the University of Virginia, and M.S. and Ph.D. degrees in Marine Studies from the University of Delaware.
Email: richard.stumpf@noaa.gov; Phone: 240-533-0338

Dr. Kate Hubbard leads the HAB monitoring and research program at the Florida Fish and Wildlife Conservation Commission-Fish and Wildlife Research Institute (FWC-FWRI). She is also a Guest Investigator at Woods Hole Oceanographic Institution as part of the NSF/NIEHS Woods Hole Center for Oceans and Human Health. FWC-FWRI's HAB program has strong ties to state and regional aquaculture management, and marine and estuarine research is also integral to Kate and her team's work. Current lab and field-based projects are focused on HAB and biotoxin detection, dynamics, modeling, and prediction. She received M.S. and Ph.D. degrees in Biological Oceanography from the University of Washington.
Email:katherine.hubbard@myfwc.com; Phone: 727-502-4961

Dr. Richard Pierce is Senior Scientist for Ecotoxicology and Associate Vice President for Research at Mote Marine Laboratory, Sarasota, FL. He received his B.A. & M.S in Chemistry from the University of South FL, and Ph.D. in Chemical Oceanography from the University of Rhode Island, GSO, followed by Postdoctoral Research in plant pathology at URI. Dr. Pierce was Assistant Professor of Environmental Science at the University of Southern Miss., and Associate Professor of Chemical Oceanography at FL Institute of Technology. He joined Mote Marine Laboratory as a Senior Scientist where he developed the research program in Ecotoxicology, focusing on the source, fate and effects of toxic chemicals in the marine environment. His studies include HAB toxins in air, water and marine organisms along the FL Gulf coast, as well as pesticides and other endocrine disrupting compounds in the FL Keys National Marine Sanctuary. He has special interest in trophic transfer and bioaccumulation of HAB toxins in shellfish, and strategies for mitigating adverse effects of toxic chemicals to environmental and public health.
Email: rich@mote.org; Phone: 941-388-4441 ext 342

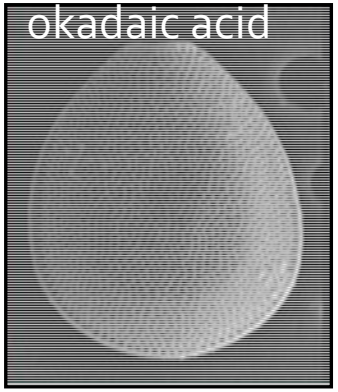
Marine HABs and their Effects on Fish and Wildlife

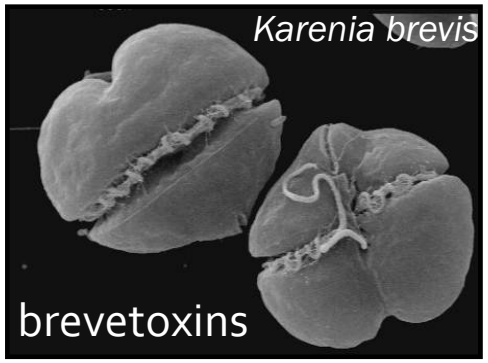


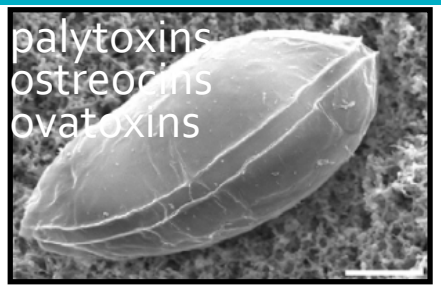
Jan H. Landsberg
Fish and Wildlife Research Institute,
Florida Fish and Wildlife Conservation Commission,
St. Petersburg, Florida

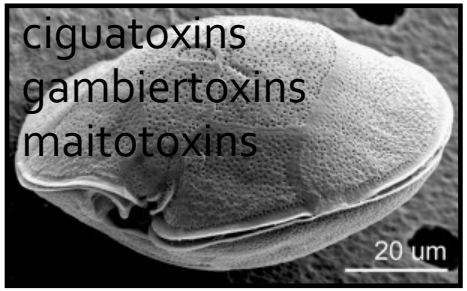
EPA Region 4 HAB Southeastern Regional Workshop, Atlanta, GA, 15 May 2018

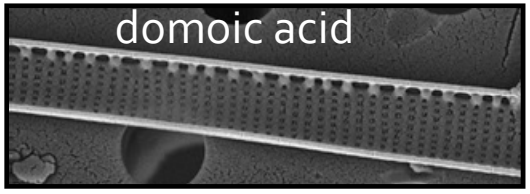
> 200 global HAB species

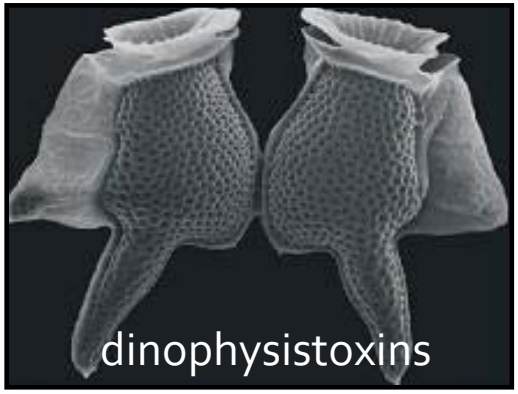


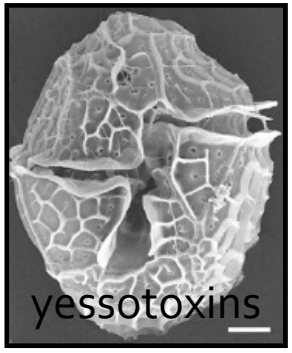


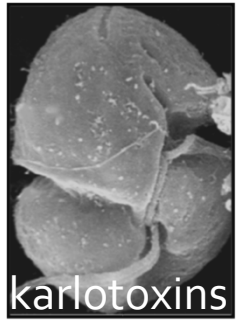












HABs: ecosystem and animal effects

Ecosystem effects

- poor water quality
- low dissolved oxygen

Animal effects

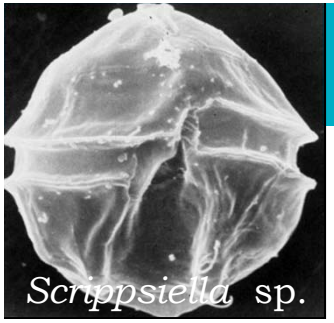
- toxins
- bioactive compounds

Ecosystem effects

- light attenuation
- smothering

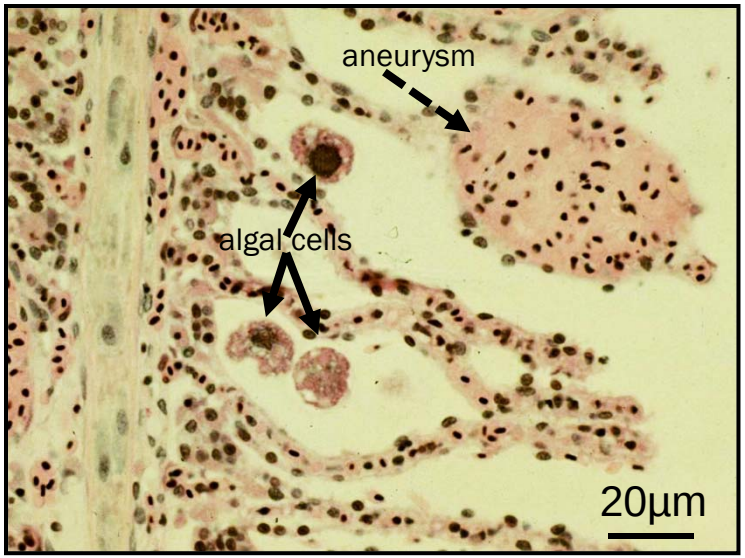
Animal effects

- mechanical
  - clogged gills
  - entry for pathogens

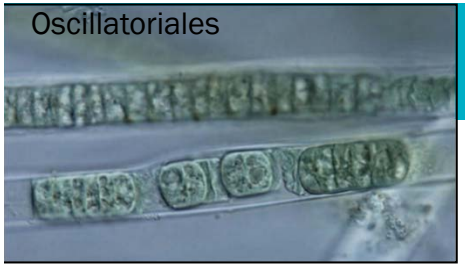


HABs: ecosystem and animal effects

- water quality
- low dissolved oxygen
- stressed fish
- clogged gills
- acute gill pathology
- congestion
- aneurysm
- fish mortalities

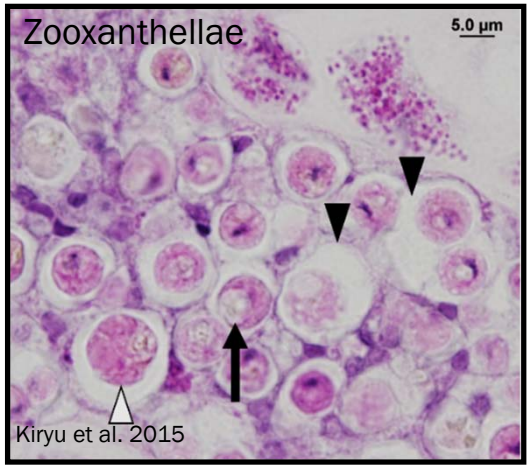


Histology section of gill



HABs: ecosystem and animal effects

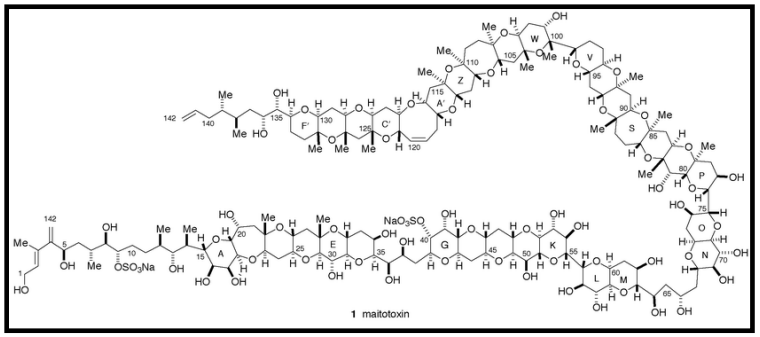
- benthic cyanobacteria
- blooms, SE Florida
- sea fan mortalities
- 2002, 2005, 2008-2009
- tissue necrosis
- zooxanthellae necrosis/vacuolation
- ? toxicity
- ?other pathogenic mechanisms



Histology section of sea fan

Paul et al. 2005, Kiryu et al. 2015

Toxins and bioactive compounds



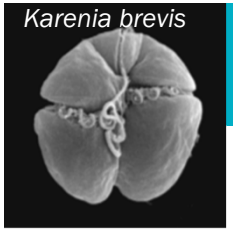
- neurotoxins
- hepatotoxins
- dermatotoxins
- bioactive compounds (e.g. hemolysins, reactive oxygen species [ROS], surfactants)
- diverse groups can produce same toxins
- some HAB species can produce multiple toxins/ bioactive compounds
- exposure primarily by ingestion (potentially by inhalation, dermal)

Scales and diversity of HAB effects

Toxin	Bioactive
• intra- or extracellular	• extracellular
• lethal (acute/chronic)	• lethal (acute)
• mass mortalities	• lower scale mortalities
• widespread distribution	• limited distribution
• limited range of spp.	• wide range of spp.
• multiple species/groups	• multiple species
• effects inverts/verts	• inverts/verts (fish/birds)
• trophic transfer	• no trophic transfer
• persistent	• transient/ephemeral
• aquatic/terrestrial	• aquatic
• many species at risk	• limited species at risk

Potential effects of HABs on fish & wildlife

- toxicosis
- pathology
- immunosuppression
- tumor promotion
- increased susceptibility to disease
- increased parasitism
- physiological dysfunction
- sub-lethal effects on growth/reproduction
- mechanical damage
- multifactorial CODs



Toxins: brevetoxins (PbTxs)

- *Karenia brevis*, Florida red tide dinoflagellate
- neurotoxins
- lipophilic, bioaccumulate, Na-channel opener
- Neurotoxic Shellfish Poisoning
- annual mortalities: millions of fish
  marine mammals, birds, sea turtles
- vectored in food chain
- kills invertebrates/benthos
- respiratory health effects
- chronic health effects
- no human fatalities
- toxins can persist weeks post bloom

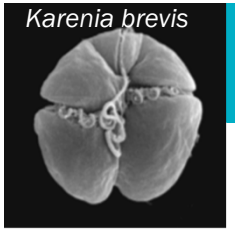
DOI: 10.7589/2012-11-299

Journal of Wildlife Diseases, 49(4), 2013, pp. 955–96

COYOTE (*CANIS LATRANS*) AND DOMESTIC DOG (*CANIS FAMILIARIS*) MORTALITY AND MORBIDITY DUE TO A *KARENIA BREVIS* RED TIDE IN THE GULF OF MEXICO

Kevin T. Castle,[1,7] Leanne J. Flewelling,[2] John Bryan II,[1] Adam Kramer,[3] James Lindsay,[4] Cheyenne Nevada,[4,6] Wade Stablein,[4] David Wong,[5] and Jan H. Landsberg[2]

[1] National Park Service, 1201 Oakridge Dr., Suite 200, Fort Collins, Colorado 80521, USA
[2] Florida Fish and Wildlife Conservation Commission, 100 8th Avenue SE, St. Petersburg, Florida 33701, USA
[3] National Park Service, 1201 Eye St. NW, 11th Floor, Washington, DC 20005, USA
[4] Padre Island National Seashore, PO Box 181300, Corpus Christi, Texas 78480, USA
[5] National Park Service, 801 Vassar Dr. NE, Albuquerque, New Mexico 87106, USA
[6] Current address: CMR 454 BOX 2188, APO AE 09250
[7] Corresponding author (email: Kevin_Castle@nps.gov)



HABs: ecosystem and animal effects

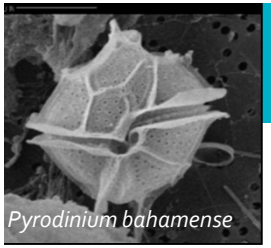
- *K. brevis* red tide, 13.5 months
- FL Keys to the Panhandle (2005-2006)
- mass mortalities:
  - manatees, bottlenose dolphins
  - sea turtles
  - seabirds

- > 50 fish species affected
- short term effects on fisheries
- >450 fish kill reports to hotline
- repeated shellfish bed closures
- benthic community die-off (~ 5600 km^2 area affected)
- 2-3 months after bloom, continued fish kills
- significant economic losses

Toxins: domoic acid (DA)

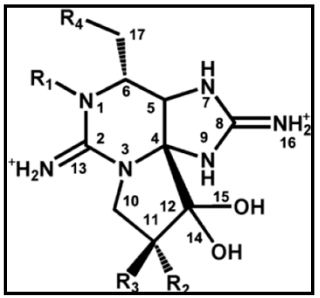
- *Pseudo-nitzschia* spp. (diatoms)
- excitatory neurotoxin
- binds to glutamate receptors
- Amnesic Shellfish Poisoning
- marine mammal mass mortalities
- primarily US west coast
- bird mortalities
- background DA in multiple spp.
- chronic health effects
- neurodegenerative, reproductive, cardiomyopathy
- DA vectored by fish prey

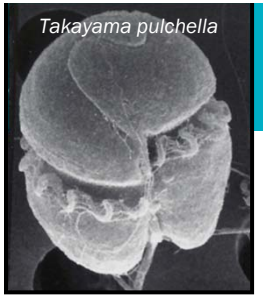
https://www.ocregister.com/2011/04/19/dead-dolphins-and-sea-lions-along-coast/



Toxins: saxitoxins (STXs)

- *Alexandrium* spp., *Pyrodinium bahamense*, *Gymnodinium catenatum* (dinoflagellates)
- neurotoxins (hydrophilic, Na-channel blocker)
- Paralytic Shellfish Poisoning
- Saxitoxin Puffer Fish Poisoning
- mass mortalities
  - humpback whales (1987)
  - sea otters (1987)
  - sea turtles (Asia, central America)
  - endangered shortnose sturgeon
- found in diverse habitats





Toxins & bioactivity: multiple species

- multimillion $$ losses in aquaculture
- widescale fish kills
- diverse habitats

"Ichthyotoxic" species

- toxins
- hemolysins
- ROS
- PUFAs

Haptophytes

Chrysochromulina sp.

Prymnesium spp.

Raphidophytes

Chattonella spp.

Fibrocapsa sp.

Heterosigma akashiwo

Dinoflagellates

Karenia mikimotoi
Karenia brevis
Karenia selliformis
Karenia digitata
Margalefidinium polykrikoides
Akashiwo sanguinea
Karlodinium veneficum
Alexandrium catenella
Alexandrium monilatum
Takayama spp.

Bioactivity: *Akashiwo sanguinea*


Photo: Takayama


Photo: J. Wigham


Photo: R. Kudela

www.oceanchampions.org/blog/wp-content/loon.jpg

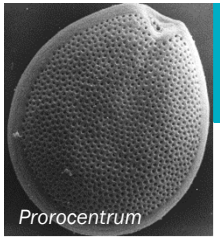
- affects seabirds
- west coast USA (CA 2007, OR 2009)
- blooms common globally
- implicated in fish kills
- extracellular bioactivity, cell lysis
- act as surfactant, foam produced
- affects water repellency & insulation


Photo: R. Kudela

Jessup et al. 2009

Emerging/unresolved issues and challenges

- expansion of toxic species
- **chronic exposure/role in disease & mortality events**
- synergistic effects > multiple toxin exposures
- **HAB toxins as tumor promoters**
- newly discovered toxins
- HABs as pathogen vectors
- **? HAB lytic bacteria and disease**
- **? HABs as contaminant vectors**
- **freshwater toxin inputs**
- unexplained animal mortalities (?novel toxins)

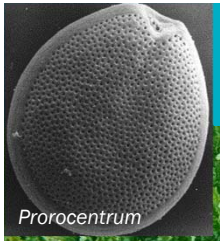


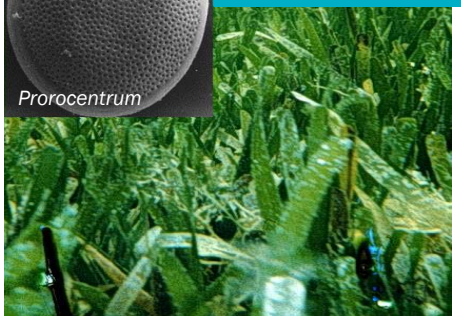
Chronic exposure/role in mortality events

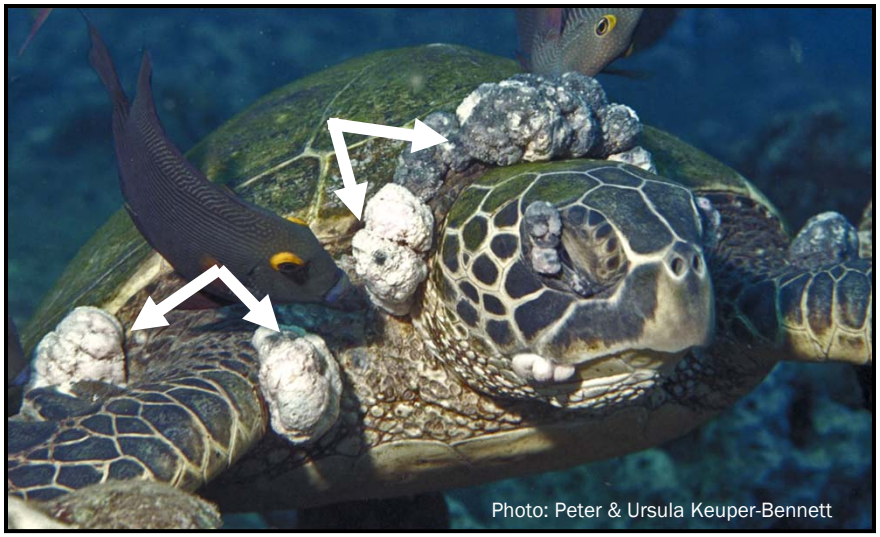
- Florida reef tract
- mass reef fish mortalities
- 1982, 1993-1994
- ~20 common fish species
- chronic disease
- multiple opportunistic pathogens
- benthic HA "blooms"
- chronic dietary toxin exposure
- ciguatoxins, OA?
- immunosuppression

Landsberg 1995

HAB toxins as tumor promoters





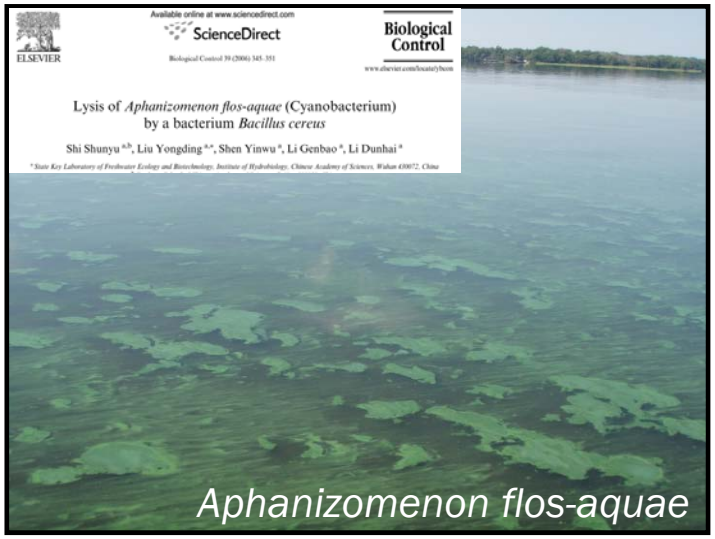


- benthic dinoflagellates
- okadaic acid
- known tumor promoter
- use seagrass/macroalgae as substrate
- sea turtles exposed through diet
- fibropapillomatosis in sea turtles (herpesvirus, HI, FL)
- ?viral initiator + okadaic acid promoter
- unresolved

Landsberg et al. 1999

HAB lytic bacteria and disease?

- St. Johns River, FL (2010)
- late May – early July
- >300 reports, 30 mile stretch
- red drum, menhaden, stingray
- chronic atypical die-off
- hundreds of fish killed
- *Aphanizomenon* bloom upstream
- > *Microcystis* bloom
- pathology ~ hemolysis
- low tissue conc. STX, CYN, MCYST
- > hemolytic activity in water
- primarily *Bacillus cereus*
- presumptive *Bacillus* in tissues



FWC, SJRWMD, unpub.

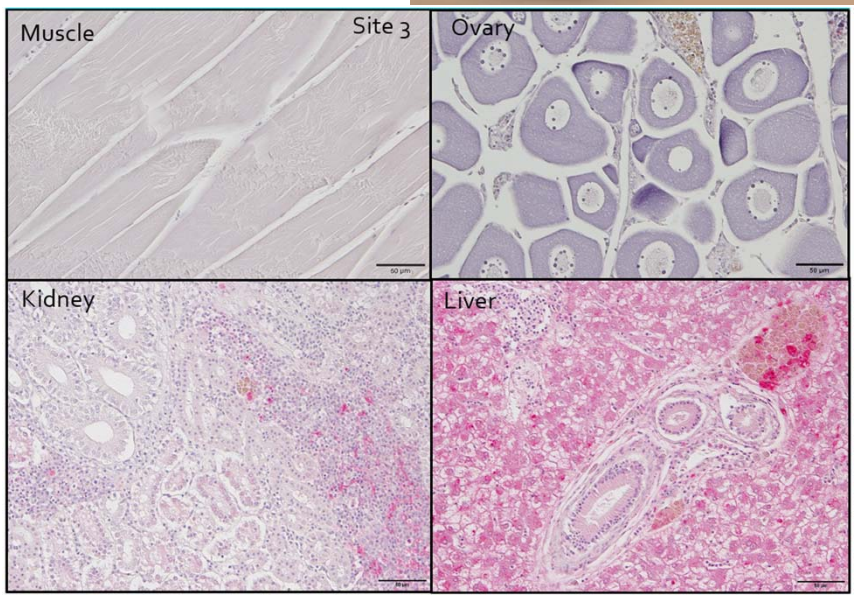
HABs as contaminant vectors?

- PBDEs (halogenated organic compounds)
- industrial flame retardants
- biogenic (sponge symbiont *Oscillatoria*)
- in cyanobacteria in Baltic Sea
- in food web (fish, mollusks)
- *Nodularia* in U.S. (Alaska)
- natural PBDEs bioaccumulate (True's beaked whale, VA)
- speculated source sponges (Teuten et al. 2005)
- risk assessment for potential animal exposure
- marine cyanobacteria in U.S. waters/migratory routes
- PBDEs in phytoplankton (coccolithophores, Fan et al. 2014)

Freshwater cyanotoxin inputs

- microcystins
- hepatotoxins
- tumor promoters
- multiple cyanobacteria spp.
- livestock, pets, fish & wildlife
- MCYST > marine systems
- all coastal areas at risk
- sea otter mortalities, CA
- water management
- release of cells/toxins
- MCYST in tissues

St. Lucie River area, June 2016



Immunohistochemistry for MCYST-LR

FWC, unpub

Acknowledgements

Florida Keys Wild Bird Sanctuary

Phytoplankton Monitoring Program along the Alabama Gulf Coast

Drew Sheehan

Alabama Department of Public Health
Bureau of Clinical Laboratories Mobile Division Laboratory

Alabama HABs- ADPH History

- 1988- FDA: The FDA required states to develop a biotoxin contingency plan for managing harmful algal blooms (HABs) in shellfish growing areas.
- 1991
  - Alabama Department of Public Health (ADPH) sent 2 Mobile Division Laboratory employees to Florida's Marine Research Institute for HAB training.
- 1996
  - The first documented *Karenia brevis* bloom, affected beaches and closed Alabama shellfish growing areas to harvest for weeks.

Alabama HABs- ADPH History

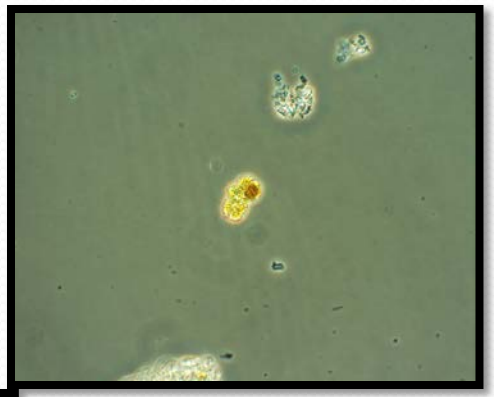
- 2000
  - *Karenia brevis* bloom near shore for a short duration
- 2004
  - *Pseudo-nitzschia* spp bloom with low level domoic acid production.
- 2007
  - *Karenia brevis* bloom affecting beaches and shellfish growing areas
  - *Pyrodinium bahamense* bloom in Portersville Bay. Toxin was present, but not at actionable levels in shellfish meats.
  - *Karlodinium veneficum* bloom in Weeks Bay that caused fish kills.

Alabama HABs- ADPH History

- 2013
  - *Pseudo-nitzschia* spp bloom in AL shellfish growing areas. Toxin levels in shellfish meats were detectable but below actionable levels.
- 2015-2016
  - *Karenia brevis* bloom that caused respiratory problems for beach goers & shellfish growing area closures.
  - Following the *K. brevis* bloom, a *Pseudo-nitzchia* bloom caused a precautionary closure of the growing areas. However, shellfish meat showed no toxin present.

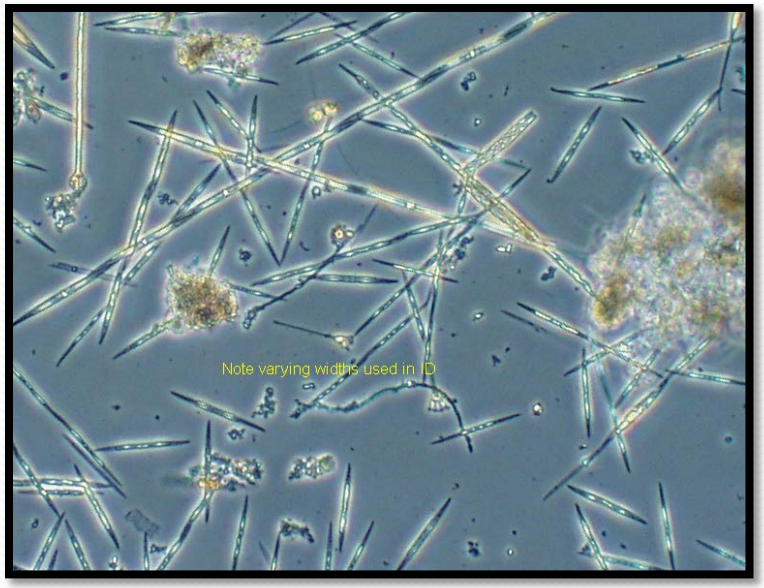
Alabama HAB Species of Concern

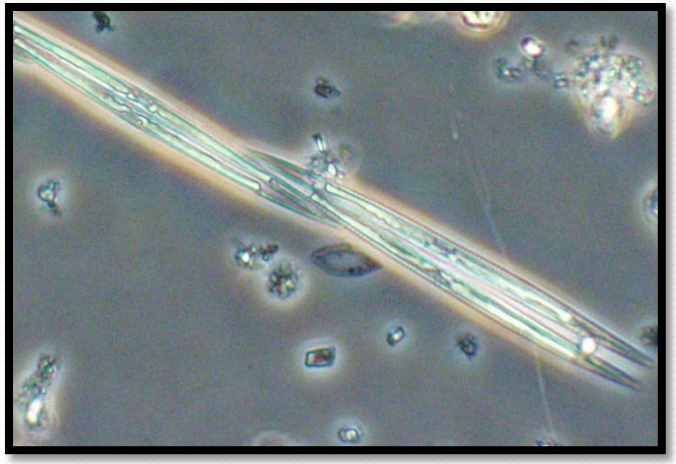
- The major HAB species seen along the Alabama Gulf Coast include:
- *Karenia brevis*, dinoflagellate
  - Brevetoxins
  - Neurotoxic Shellfish Poisoning (NSP)



Alabama HAB Species of Concern

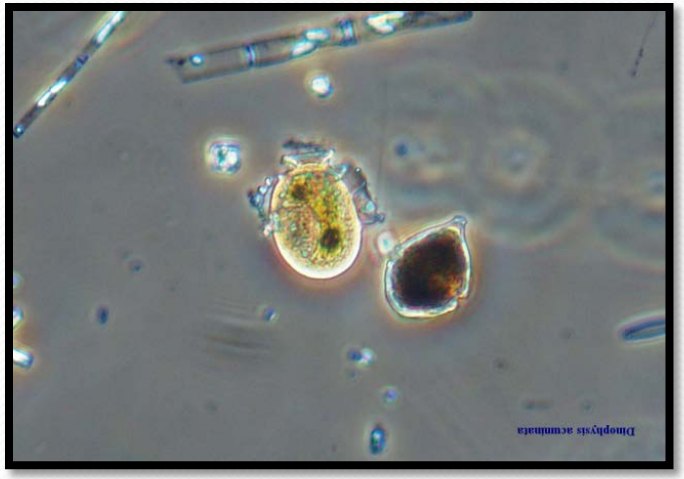
- *Pseudo-nitzschia*, diatom
  - Domoic Acid
  - Amnesiac Shellfish Poisoning (ASP)

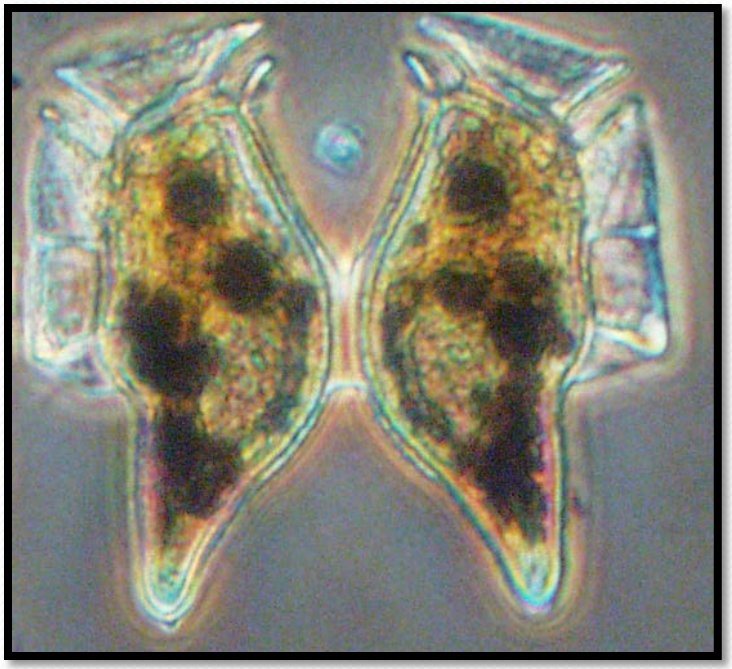




Alabama HAB Species of Concern

- *Dinophysis* spp.
  - Okadaic Acid (OA)
  - Diarrheic Shellfish Poisoning (DSP)





Alabama Phytoplankton Sampling Program

- The program monitors for phytoplankton routinely
  - Along the Gulf Coast though our BEACH program and at the key shellfish growing water areas.
- All samples are viewed quantitatively.
- The laboratory identifies and enumerates dinoflagellates to genus and species when possible and Diatoms are identified to genus when counts exceed background levels.

Alabama Microscopic Technique

- Samples are collected and delivered to the lab in a 1 liter glass container, preserved with approx. 7 ml of acidified Lugol's iodine.
- Samples are then dispensed into an 11 ml Nunc chamber.
  - Allow 30 minutes per ½ inch depth of sample to settle.
- Samples are then examined under an inverted light microscope.

Alabama Sampling Frequency

- The key Shellfish growing water stations are sampled at least 5 times per year by ADPH Seafood Branch.
  - Sample frequency increases in the event of a bloom.

- Samples are collected along the Gulf Coast at the EPA BEACH sites by Baldwin County Health Department and Alabama Department of Environmental Management (ADEM).
  - Samples are collected weekly during active swimming season and monthly during the winter.

The ADPH HAB Response Plan

- Following the 2007 *Karenia brevis* bloom a AL HAB Response Plan was developed. Main goal was to:
  - Provide accurate information regarding bloom to local, state, federal and academic agencies in Alabama
  - Provide timely health advisories associated with HAB and human health.
  - Assure regulation of the shellfish harvest as required by the Marine Biotoxin Control Plan within the National Shellfish Sanitation Program (NSSP).
  - Define contacts and roles within county, state and federal agencies that respond to HAB events
  - Provide, in a timely manner, accurate analyses of toxins and organisms using standardized methodologies for identification and enumeration
  - Maintain databases of HAB monitoring and event response data in Alabama coastal waters

Alabama HABs Lab - Database

Date	Time (GMT) CST+5	Station Description	County	N Latitude	W Longitude	Total Water Depth (ft)	Water Temperature (°C)	Salinity (ppt)	Karenia cells/L	Notes
12/1/2015	14:35:00 PM	Florida Point	Baldwin	30.273	87.5509		21.3	21.8	1,000,000	
12/1/2015	14:50:00 PM	Alabama Point	Baldwin	30.2728	87.5383		22.2	28.8	14,000,000	Respiratory irritation reported
12/1/2015	14:20:00 PM	Cotton Bayou	Baldwin	30.2695	87.582		23.5	30.8	300,000	
12/1/2015	15:07:00 PM	Gulf State Park Pavilion	Baldwin	30.25472	87.64333		22.2	30.4	210,00	Respiratory irritation reported
12/1/2015	15:22:00 PM	Gulf Shores Public Beach	Baldwin	30.242	87.6761		**22.2**	30.1	620,000	
12/1/2015	16:15:00 PM	Fort Morgan Beach	Baldwin	30.2221	88.0057		22.7	29.8	8,000,000	
12/1/2015	16:45:00 PM	Bon Secour National Wildlife Refuge	Baldwin	30.1344	87.4953		22.8	30.1	5,300,000	Respiratory irritation reported
12/1/2015	15:30:00 PM	Little Lagoon	Baldwin	30.2382	87.736		21	25.9	210,000	
12/1/2015	14:50:00 PM	Dauphin Island East End	Mobile	30.2463	88.0825			12.6	Not Present	
12/1/2015	14:25:00 PM	Dauphin Island Public Beach	Mobile	30.242	88.123			19.4	440,000	

Alabama Biotoxin Monitoring

- Biotoxins are monitored during/after a HAB event.
  - Oyster meats are tested to show that toxin levels are below actionable levels so that growing water areas can be opened for harvest.

Alabama Sampling Partners

- Alabama Department of Public Health (ADPH)
  - Seafood Branch
  - Baldwin Co. Health Department
  - Mobile Division Laboratory
- Alabama Department of Environmental Management (ADEM)
- Alabama Department of Conservation and Natural Resources – Marine Resources (ADCNR)
- Dauphin Island Sea Lab (DISL)
- FDA Seafood Research Lab

Alabama HABs – ADPH - Seafood

- ADPH Environmental Services - Seafood Branch
  - Responsibilities for the opening and closing of oyster growing areas for harvest.
  - Collect growing water, oyster meat and HAB samples.
  - Permitting of aquaculture sites and processing plants.
  - Manage the ADPH response to HABs in Alabama waters.

Alabama HABs- ADPH

- Baldwin Co. HD helped with Public Health Advisory publication and sampling.
- Central Office Toxicology answers questions from the public.
- The Bureau of Clinical Laboratories-Mobile Division performs microscopic exams, recorded data, and distributed results.

Alabama HABs Partners – DISL

- *Karenia brevis* bloom of 2015-2016
  - Dauphin Island Sea Lab
    - Brevetoxin research using alternative methods
    - Analysis of shellfish and growing waters to compare toxin levels to cell counts

Alabama Closure Criteria

- *Karenia brevis* -
  - Cell counts exceed 5,000 cells per liter
- *Pseudo-nitzschia* –
  - Precautionary closure at 1,000,000 cells per liter
  - Closure when 2 mg domoic acid/100 grams (20 ppm) in the edible portion of raw shellfish

Alabama Closures

- Once a *Karenia brevis* bloom exceeds 5,000 cells per liter in AL waters, all shellfish growing areas are closed for harvest.
  - When Seafood Branch environmentalists are notified of a HAB event, they notify Conservation-Marine Resources so that no more oysters are harvested.
  - Marine Resources confiscates product harvested earlier in the day so that public health risk is reduced. The oysters are returned to the reef.
  - Notify FDA of the closure.
  - At this time there is an increase in sampling with the help of our partner agencies.

Re-opening of Growing Areas

- Once samples begin showing cell counts below 5,000 cells per liter. Shellfish meat samples are sent for testing using the Mouse Bioassay (MBA).
  - Toxin testing using Mouse Bioassay is a specialty test performed for AL by Florida, Maine, or Texas certified labs.
  - Growing areas are re-opened by order of the State Health Officer when toxin levels fall below FDA recommended level of 20 mouse units/100 grams.

Alabama HABs

- Credits
  - Mobile Lab Staff
  - ADPH Seafood Branch
  - Agency Partners
    - ADCNR- Marine Resources- Gulf Shores and Dauphin Island
    - ADEM
    - Baldwin County Health Department
    - Dauphin Island Sea Lab
    - FDA Seafood Lab
  - Neighboring States
    - Mississippi Dept. of Marine Resources
    - Florida Fish and Wildlife Conservation Commission

Alabama HABs - ADPH

- Questions?

Public Health Response to Marine Harmful Algal Blooms in Florida

Environmental Protection Agency Region 4 Harmful Algal Bloom
Southeast Regional Workshop May 14- 16, 2018

Andrew Reich, MS, MSPH, RRT
Scientific Advisor
Bureau of Environmental Health

Fun in Florida

Exposures

Potential Exposure Pathways

Direct Skin Contact

Ingestion of Food

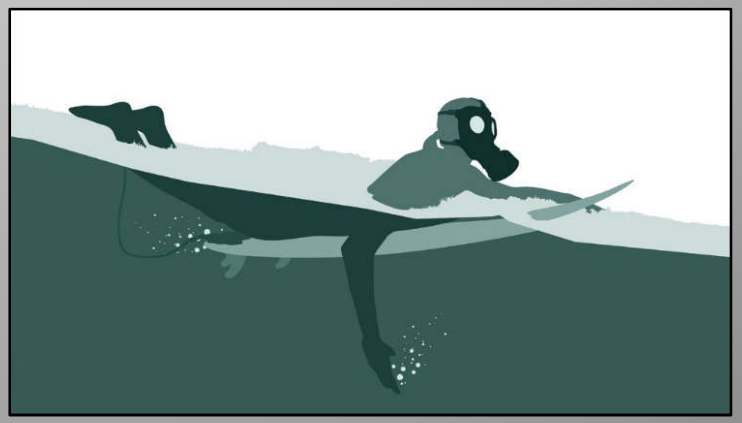
Incidental Ingestion

Drinking Water

Inhalation of Aerosols

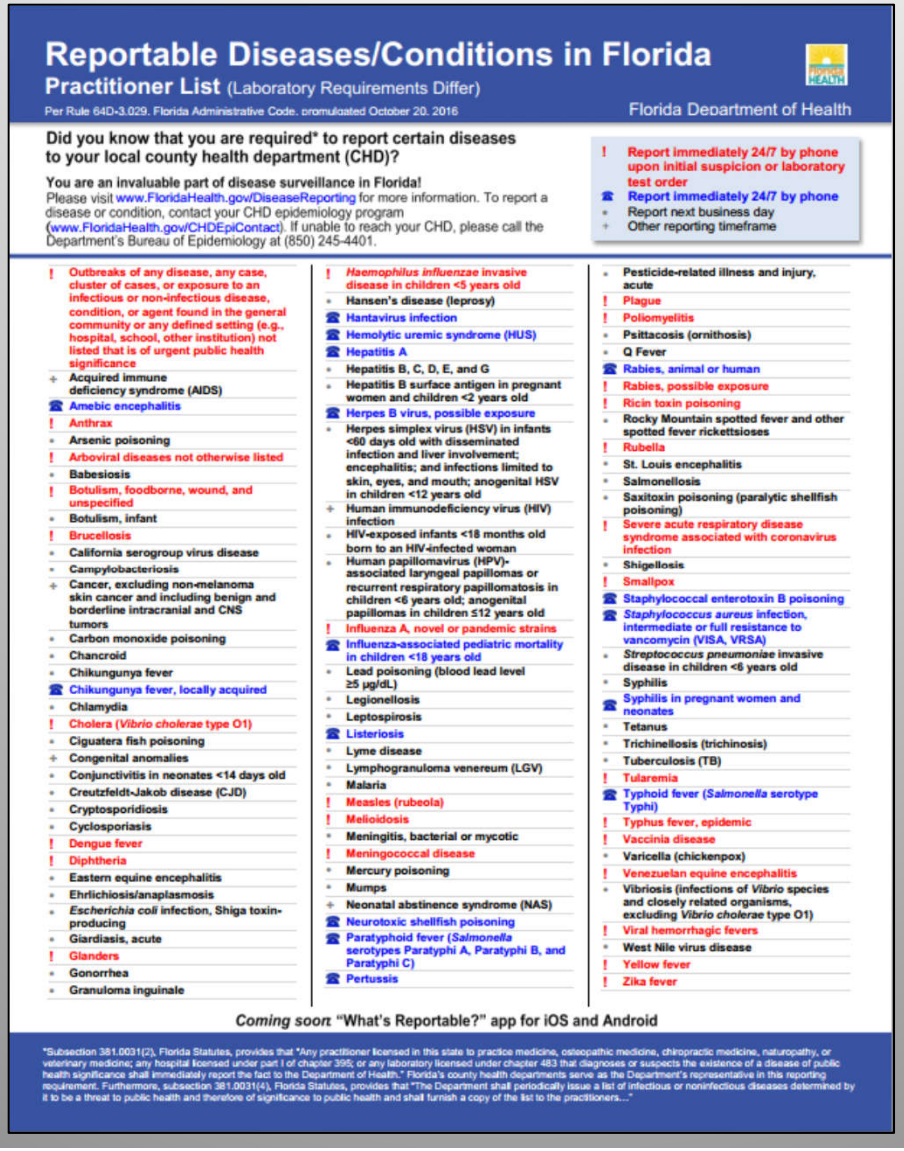
Marine Aquatic Toxins from Harmful Algal Blooms (HABs)

- Microscopic organisms (mostly)
- Brevetoxins, saxitoxins, ciguatoxins, Palytoxins
- Characteristics
  - ✓ No taste or smell
  - ✓ Heat, acid stable
  - ✓ Very potent



Florida HEALTH

Reportable Diseases in Florida



Reportable Diseases/Conditions in Florida

Practitioner List (Laboratory Requirements Differ)

Per Rule 64D-3.029, Florida Administrative Code, promulgated October 20, 2016

Florida Department of Health

Did you know that you are required* to report certain diseases to your local county health department (CHD)?

You are an invaluable part of disease surveillance in Florida!
Please visit www.FloridaHealth.gov/DiseaseReporting for more information. To report a disease or condition, contact your CHD epidemiology program (www.FloridaHealth.gov/CHDEpiContact). If unable to reach your CHD, please call the Department's Bureau of Epidemiology at (850) 245-4401.

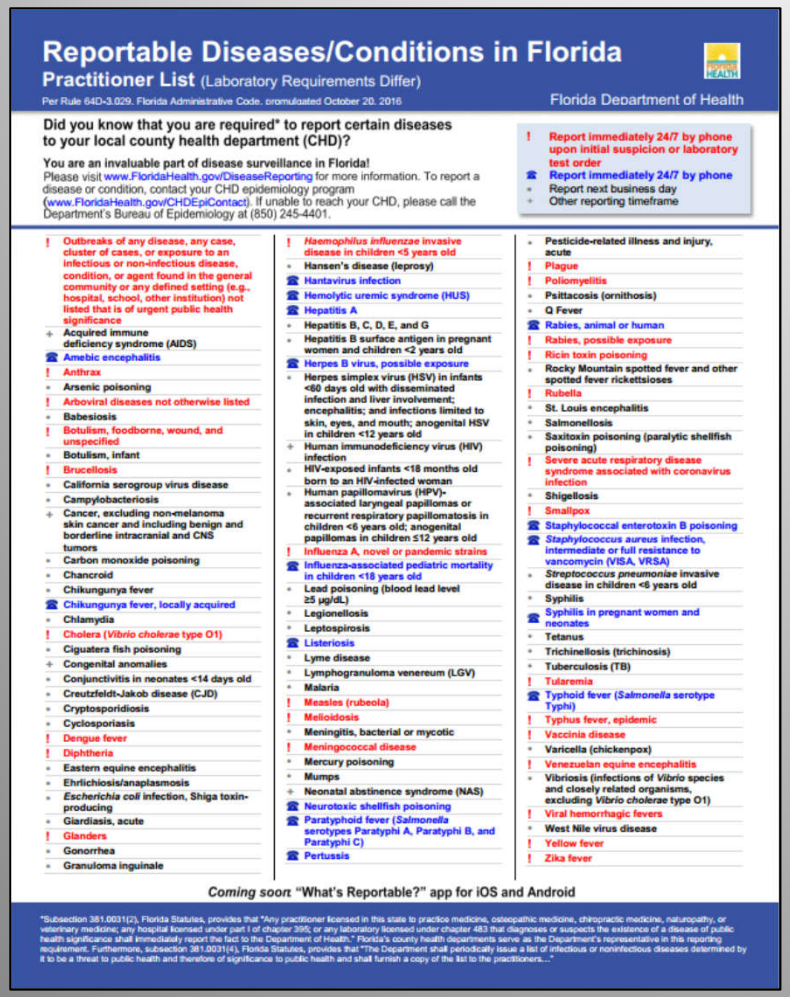
! Report immediately 24/7 by phone upon initial suspicion or laboratory test order
☎ Report immediately 24/7 by phone
▪ Report next business day
+ Other reporting timeframe

- ! Outbreaks of any disease, any case, cluster of cases, or exposure to an infectious or non-infectious disease, condition, or agent found in the general community or any defined setting (e.g., hospital, school, other institution) not listed that is of urgent public health significance
- + Acquired immune deficiency syndrome (AIDS)
- ☎ Amebic encephalitis
- ! Anthrax
- ▪ Arsenic poisoning
- ! Arboviral diseases not otherwise listed
- ▪ Babesiosis
- ! Botulism, foodborne, wound, and unspecified
- ▪ Botulism, infant
- ! Brucellosis
- ▪ California serogroup virus disease
- ▪ Campylobacteriosis
- + Cancer, excluding non-melanoma skin cancer and including benign and borderline intracranial and CNS tumors
- ▪ Carbon monoxide poisoning
- ▪ Chancroid
- ▪ Chikungunya fever
- ☎ Chikungunya fever, locally acquired
- ▪ Chlamydia
- ! Cholera (*Vibrio cholerae* type O1)
- ▪ Ciguatera fish poisoning
- + Congenital anomalies
- ▪ Conjunctivitis in neonates <14 days old
- ▪ Creutzfeldt-Jakob disease (CJD)
- ▪ Cryptosporidiosis
- ▪ Cyclosporiasis
- ! Dengue fever
- ! Diphtheria
- ▪ Eastern equine encephalitis
- ▪ Ehrlichiosis/anaplasmosis
- ▪ *Escherichia coli* infection, Shiga toxin-producing
- ▪ Giardiasis, acute
- ! Glanders
- ▪ Gonorrhea
- ▪ Granuloma inguinale
- ! *Haemophilus influenzae* invasive disease in children <5 years old
- ▪ Hansen's disease (leprosy)
- ☎ Hantavirus infection
- ☎ Hemolytic uremic syndrome (HUS)
- ☎ Hepatitis A
- ▪ Hepatitis B, C, D, E, and G
- ▪ Hepatitis B surface antigen in pregnant women and children <2 years old
- ☎ Herpes B virus, possible exposure
- ▪ Herpes simplex virus (HSV) in infants <60 days old with disseminated infection and liver involvement; encephalitis; and infections limited to skin, eyes, and mouth; anogenital HSV in children <12 years old
- + Human immunodeficiency virus (HIV) infection
- ▪ HIV-exposed infants <18 months old born to an HIV-infected woman
- ▪ Human papillomavirus (HPV)-associated laryngeal papillomas or recurrent respiratory papillomatosis in children <6 years old; anogenital papillomas in children ≤12 years old
- ! Influenza A, novel or pandemic strains
- ☎ Influenza-associated pediatric mortality in children <18 years old
- ▪ Lead poisoning (blood lead level ≥5 µg/dL)
- ▪ Legionellosis
- ▪ Leptospirosis
- ☎ Listeriosis
- ▪ Lyme disease
- ▪ Lymphogranuloma venereum (LGV)
- ▪ Malaria
- ! Measles (rubeola)
- ! Melioidosis
- ▪ Meningitis, bacterial or mycotic
- ! Meningococcal disease
- ▪ Mercury poisoning
- ▪ Mumps
- + Neonatal abstinence syndrome (NAS)
- ☎ Neurotoxic shellfish poisoning
- ☎ Paratyphoid fever (*Salmonella* serotypes Paratyphi A, Paratyphi B, and Paratyphi C)
- ☎ Pertussis
- ▪ Pesticide-related illness and injury, acute
- ! Plague
- ! Poliomyelitis
- ▪ Psittacosis (ornithosis)
- ▪ Q Fever
- ☎ Rabies, animal or human
- ! Rabies, possible exposure
- ! Ricin toxin poisoning
- ▪ Rocky Mountain spotted fever and other spotted fever rickettsioses
- ! Rubella
- ▪ St. Louis encephalitis
- ▪ Salmonellosis
- ▪ Saxitoxin poisoning (paralytic shellfish poisoning)
- ! Severe acute respiratory disease syndrome associated with coronavirus infection
- ▪ Shigellosis
- ! Smallpox
- ☎ Staphylococcal enterotoxin B poisoning
- ☎ *Staphylococcus aureus* infection, intermediate or full resistance to vancomycin (VISA, VRSA)
- ▪ *Streptococcus pneumoniae* invasive disease in children <6 years old
- ▪ Syphilis
- ☎ Syphilis in pregnant women and neonates
- ▪ Tetanus
- ▪ Trichinellosis (trichinosis)
- ▪ Tuberculosis (TB)
- ! Tularemia
- ☎ Typhoid fever (*Salmonella* serotype Typhi)
- ! Typhus fever, epidemic
- ! Vaccinia disease
- ▪ Varicella (chickenpox)
- ! Venezuelan equine encephalitis
- ▪ Vibriosis (infections of *Vibrio* species and closely related organisms, excluding *Vibrio cholerae* type O1)
- ! Viral hemorrhagic fevers
- ▪ West Nile virus disease
- ! Yellow fever
- ! Zika fever

Coming soon "What's Reportable?" app for iOS and Android

*Subsection 381.0031(2), Florida Statutes, provides that "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." Florida's county health departments serve as the Department's representative in this reporting requirement. Furthermore, subsection 381.0031(4), Florida Statutes, provides that "The Department shall periodically 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..."

Reportable Diseases in Florida



Reportable Diseases/Conditions in Florida

Practitioner List (Laboratory Requirements Differ)

Per Rule 64D-3.029, Florida Administrative Code, promulgated October 20, 2016

Florida Department of Health

Did you know that you are required* to report certain diseases to your local county health department (CHD)?

You are an invaluable part of disease surveillance in Florida!
Please visit www.FloridaHealth.gov/DiseaseReporting for more information. To report a disease or condition, contact your CHD epidemiology program (www.FloridaHealth.gov/CHDEpiContact). If unable to reach your CHD, please call the Department's Bureau of Epidemiology at (850) 245-4401.

- ! Report immediately 24/7 by phone upon initial suspicion or laboratory test order
- ☎ Report immediately 24/7 by phone
- • Report next business day
- + Other reporting timeframe

- ! Outbreaks of any disease, any case, cluster of cases, or exposure to an infectious or non-infectious disease, condition, or agent found in the general community or any defined setting (e.g., hospital, school, other institution) not listed that is of urgent public health significance
- + Acquired immune deficiency syndrome (AIDS)
- ☎ Amebic encephalitis
- ! Anthrax
- • Arsenic poisoning
- ! Arboviral diseases not otherwise listed
- • Babesiosis
- ! Botulism, foodborne, wound, and unspecified
- • Botulism, infant
- ! Brucellosis
- • California serogroup virus disease
- • Campylobacteriosis
- + Cancer, excluding non-melanoma skin cancer and including benign and borderline intracranial and CNS tumors
- • Carbon monoxide poisoning
- • Chancroid
- • Chikungunya fever
- ☎ Chikungunya fever, locally acquired
- • Chlamydia
- ! Cholera (*Vibrio cholerae* type O1)
- • Ciguatera fish poisoning
- + Congenital anomalies
- • Conjunctivitis in neonates <14 days old
- • Creutzfeldt-Jakob disease (CJD)
- • Cryptosporidiosis
- • Cyclosporiasis
- ! Dengue fever
- ! Diphtheria
- • Eastern equine encephalitis
- • Ehrlichiosis/anaplasmosis
- • *Escherichia coli* infection, Shiga toxin-producing
- • Giardiasis, acute
- ! Glanders
- • Gonorrhea
- • Granuloma inguinale
- ! *Haemophilus influenzae* invasive disease in children <5 years old
- • Hansen's disease (leprosy)
- ☎ Hantavirus infection
- ☎ Hemolytic uremic syndrome (HUS)
- ☎ Hepatitis A
- • Hepatitis B, C, D, E, and G
- • Hepatitis B surface antigen in pregnant women and children <2 years old
- ☎ Herpes B virus, possible exposure
- • Herpes simplex virus (HSV) in infants <60 days old with disseminated infection and liver involvement; encephalitis; and infections limited to skin, eyes, and mouth; anogenital HSV in children <12 years old
- + Human immunodeficiency virus (HIV) infection
- • HIV-exposed infants <18 months old born to an HIV-infected woman
- • Human papillomavirus (HPV)-associated laryngeal papillomas or recurrent respiratory papillomatosis in children <6 years old; anogenital papillomas in children ≤12 years old
- ! Influenza A, novel or pandemic strains
- ☎ Influenza-associated pediatric mortality in children <18 years old
- • Lead poisoning (blood lead level ≥5 µg/dL)
- • Legionellosis
- • Leptospirosis
- ☎ Listeriosis
- • Lyme disease
- • Lymphogranuloma venereum (LGV)
- • Malaria
- ! Measles (rubeola)
- ! Melioidosis
- • Meningitis, bacterial or mycotic
- ! Meningococcal disease
- • Mercury poisoning
- • Mumps
- + Neonatal abstinence syndrome (NAS)
- ☎ Neurotoxic shellfish poisoning
- ☎ Paratyphoid fever (*Salmonella* serotypes Paratyphi A, Paratyphi B, and Paratyphi C)
- ☎ Pertussis
- • Pesticide-related illness and injury, acute
- ! Plague
- ! Poliomyelitis
- • Psittacosis (ornithosis)
- • Q Fever
- ☎ Rabies, animal or human
- ! Rabies, possible exposure
- ! Ricin toxin poisoning
- • Rocky Mountain spotted fever and other spotted fever rickettsioses
- ! Rubella
- • St. Louis encephalitis
- • Salmonellosis
- • Saxitoxin poisoning (paralytic shellfish poisoning)
- ! Severe acute respiratory disease syndrome associated with coronavirus infection
- • Shigellosis
- ! Smallpox
- ☎ Staphylococcal enterotoxin B poisoning
- ☎ *Staphylococcus aureus* infection, intermediate or full resistance to vancomycin (VISA, VRSA)
- • *Streptococcus pneumoniae* invasive disease in children <6 years old
- • Syphilis
- ☎ Syphilis in pregnant women and neonates
- • Tetanus
- • Trichinellosis (trichinosis)
- • Tuberculosis (TB)
- ! Tularemia
- ☎ Typhoid fever (*Salmonella* serotype Typhi)
- ! Typhus fever, epidemic
- ! Vaccinia disease
- • Varicella (chickenpox)
- ! Venezuelan equine encephalitis
- • Vibriosis (infections of *Vibrio* species and closely related organisms, excluding *Vibrio cholerae* type O1)
- ! Viral hemorrhagic fevers
- • West Nile virus disease
- ! Yellow fever
- ! Zika fever

Coming soon "What's Reportable?" app for iOS and Android

*Subsection 381.0031(2), Florida Statutes, provides that "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." Florida's county health departments serve as the Department's representative in this reporting requirement. Furthermore, subsection 381.0031(4), Florida Statutes, provides that "The Department shall periodically 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..."

Neurotoxic Shellfish Poisoning

Paralytic Shellfish (and Pufferfish) Poisoning

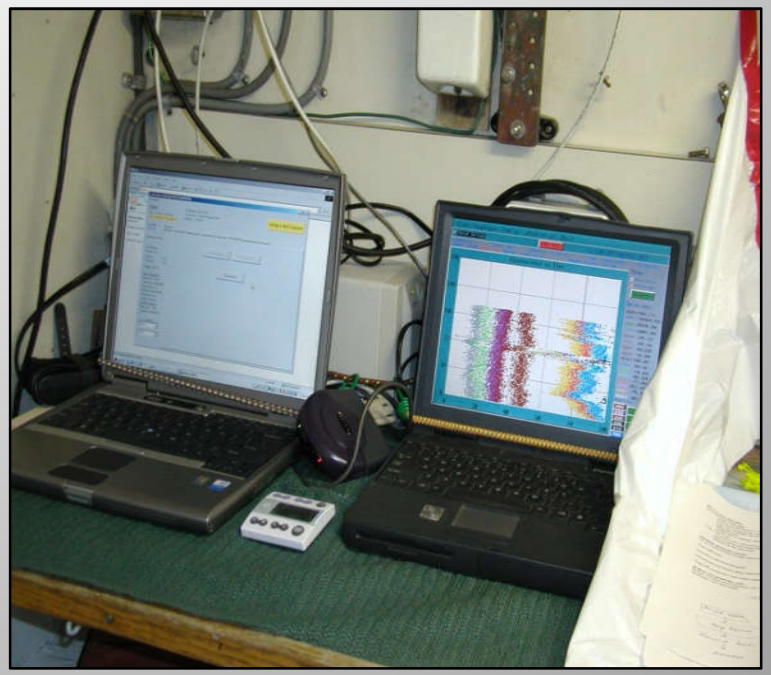
Ciguatera Fish Poisoning

Neurotoxic Shellfish Poisoning

- *Karenia brevis* Red Tide
  Brevetoxins

Florida Institute of Oceanography

Rosette Placement

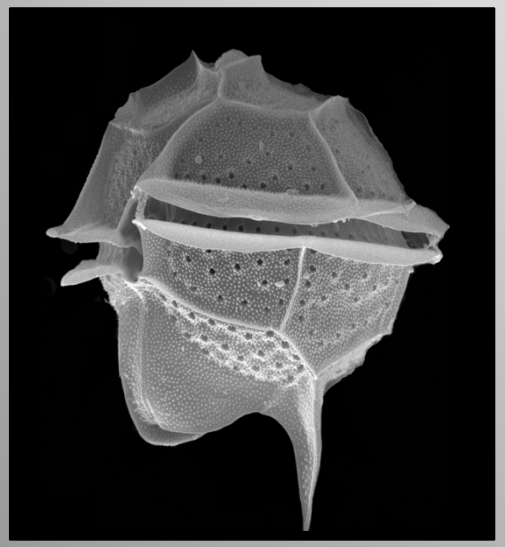


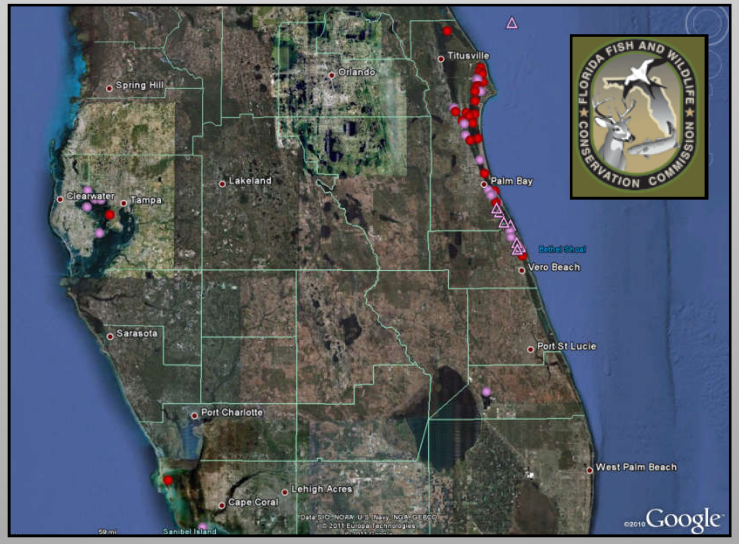
Filtering Samples

Cell Counts

Paralytic Shellfish Poisoning

- *Pyrodinium bahamense*
  - ✓ Saxitoxin





Paralytic Shellfish Poisoning

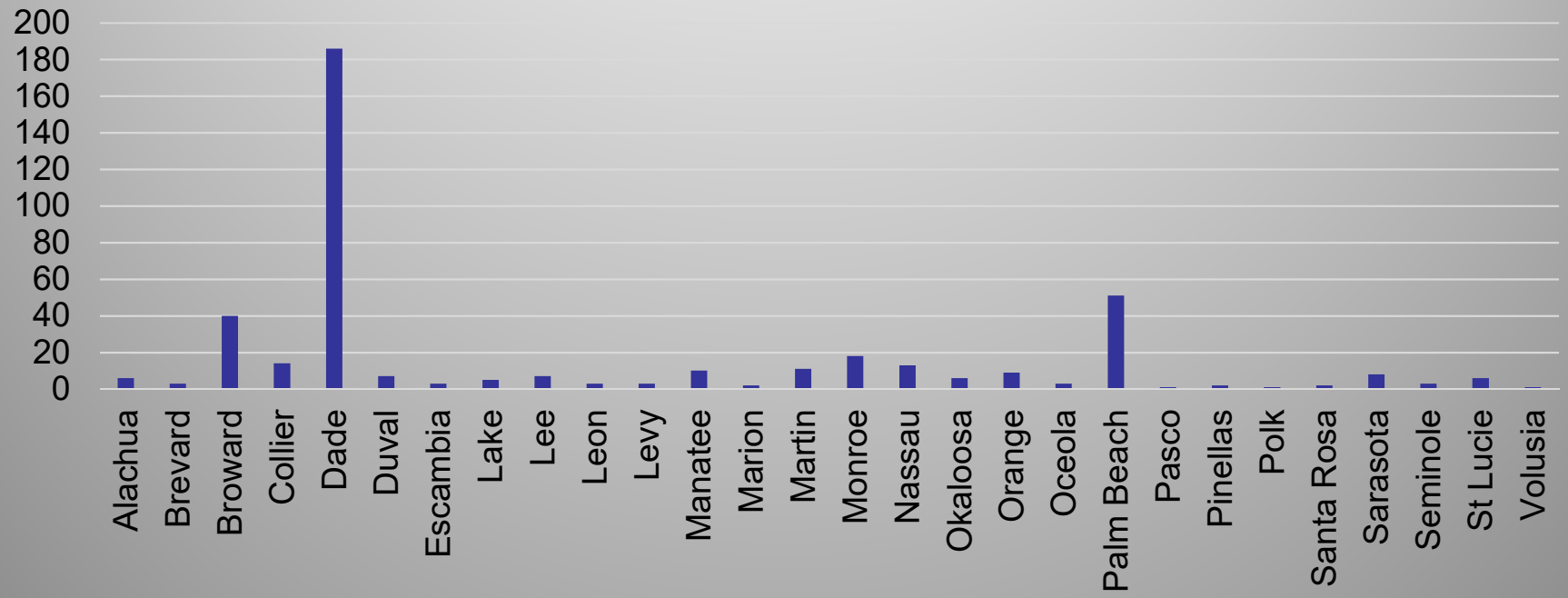
“Bioluminescence”

Ciguatera Fish Poisoning

- *Gamberdiscus toxicus*

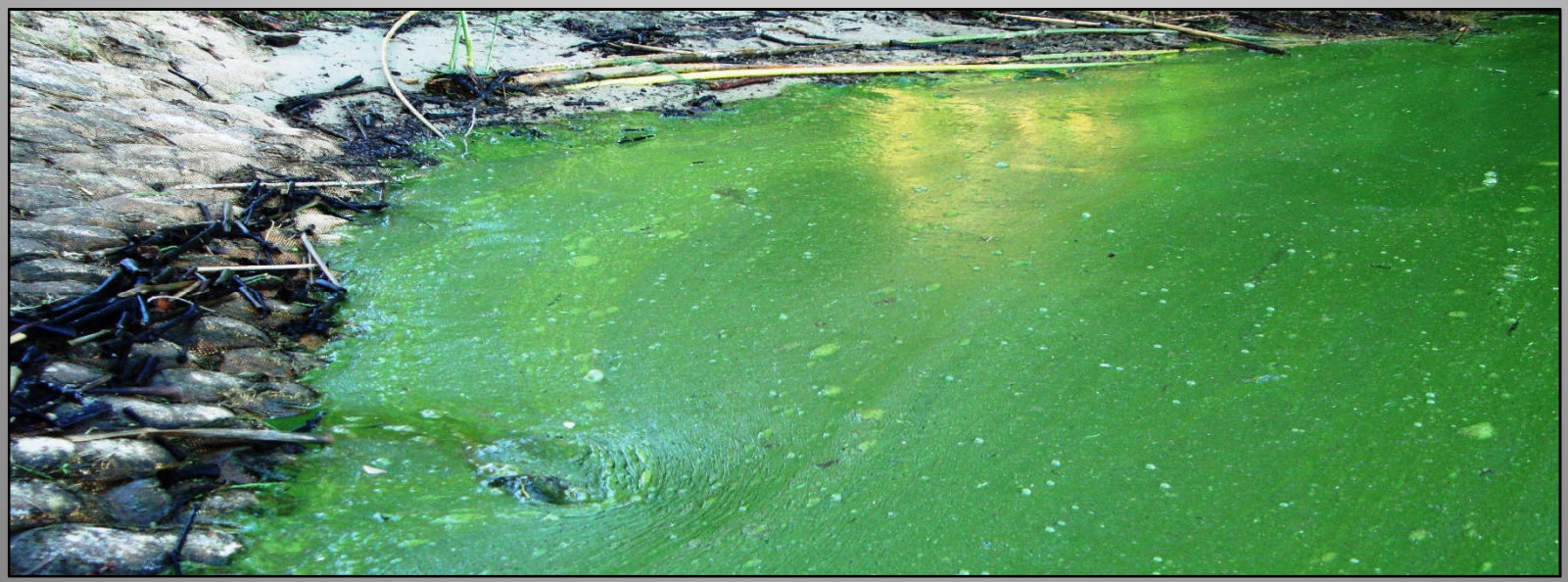
Ciguatera Cases by County

Merlin: 2006 – 2016
n = 424

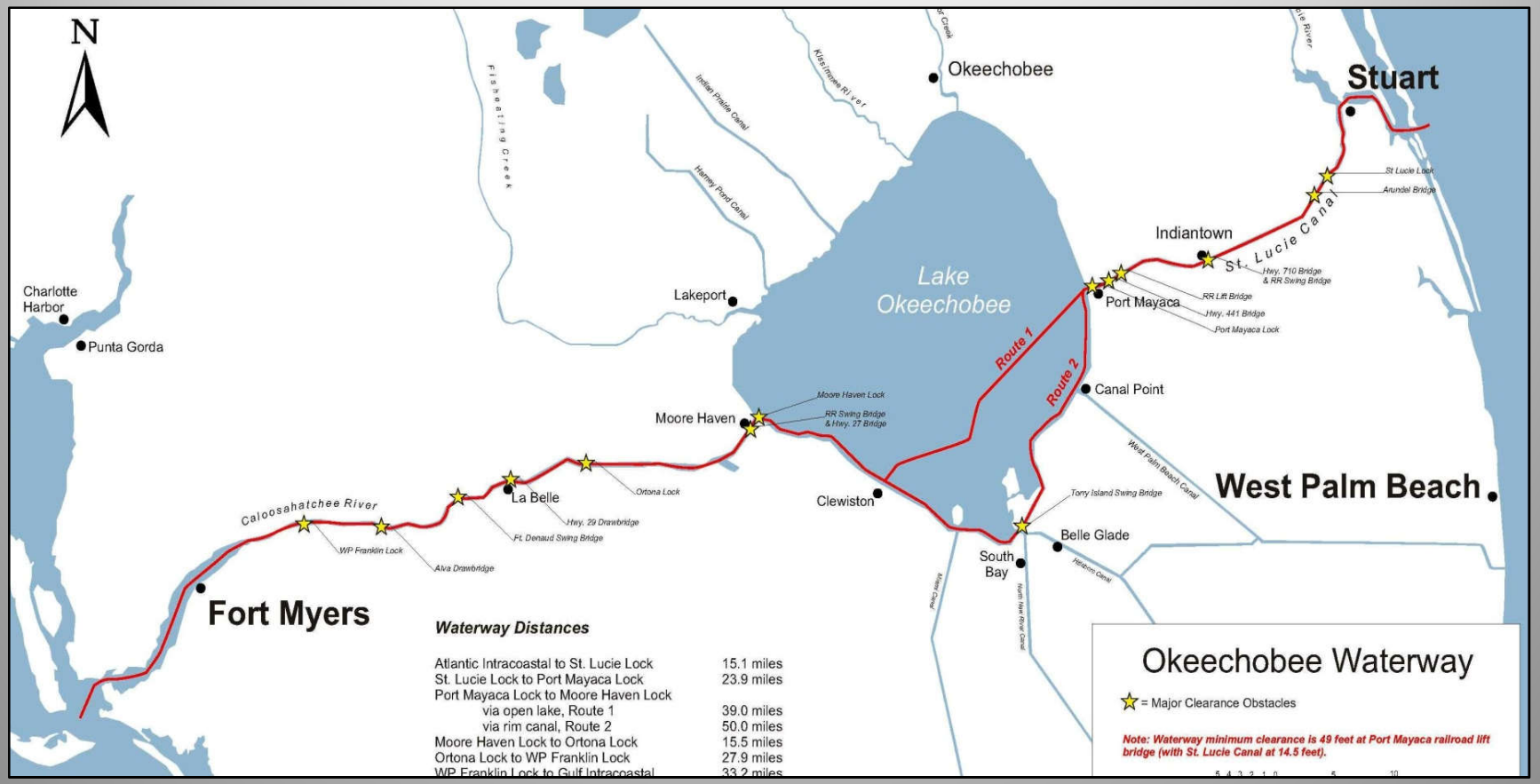


Freshwater: Cyanobacteria

- *Microcystis, Anabaena, Cylindrospermopsis Oscillatoria, Aphanizomenon*
- Cyanotoxins: microcystins, cylindrospermosins, anatoxins, etc.



Lake Okeechobee Waterway



Lake Okeechobee

NASA Earth Observatory July 2, 2016

Lake Okeechobee Discharge

Red Fish Pass, Captiva Island, Lee County

Lake Okeechobee Discharge

St. Lucie River, Martin County

Martin County

Martin County

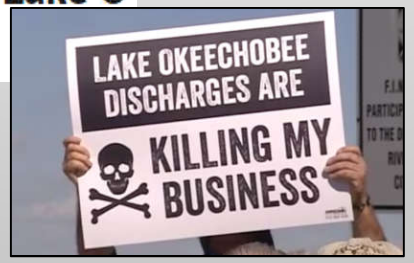
Martin County

Media

Senator Bill Nelson calls Lake Okeechobee water releases 'idiotic'

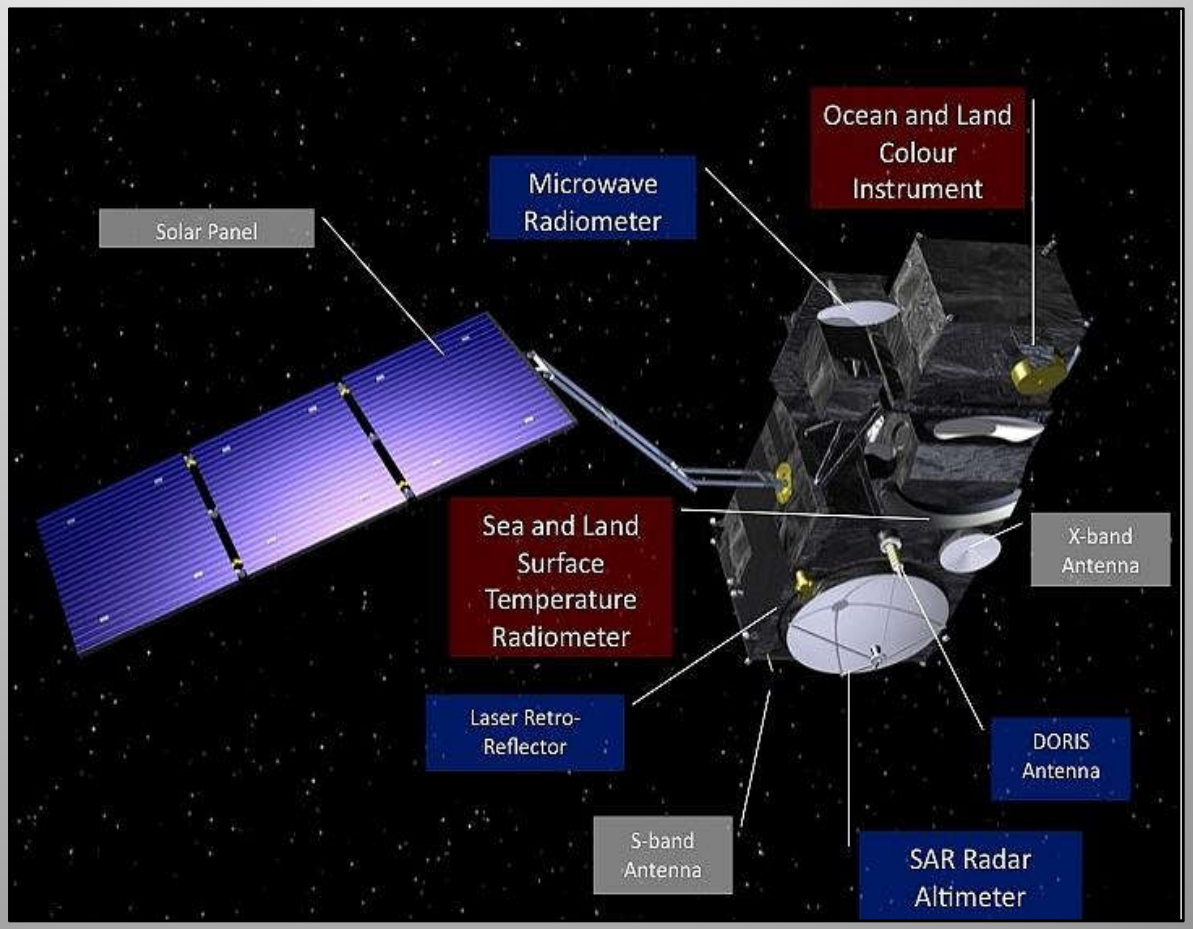
BY JANA ESCHBACH (WPEC) | FRIDAY, FEBRUARY 19TH 2016

Businesses, charter captains protest Lake O 'catastrophe'

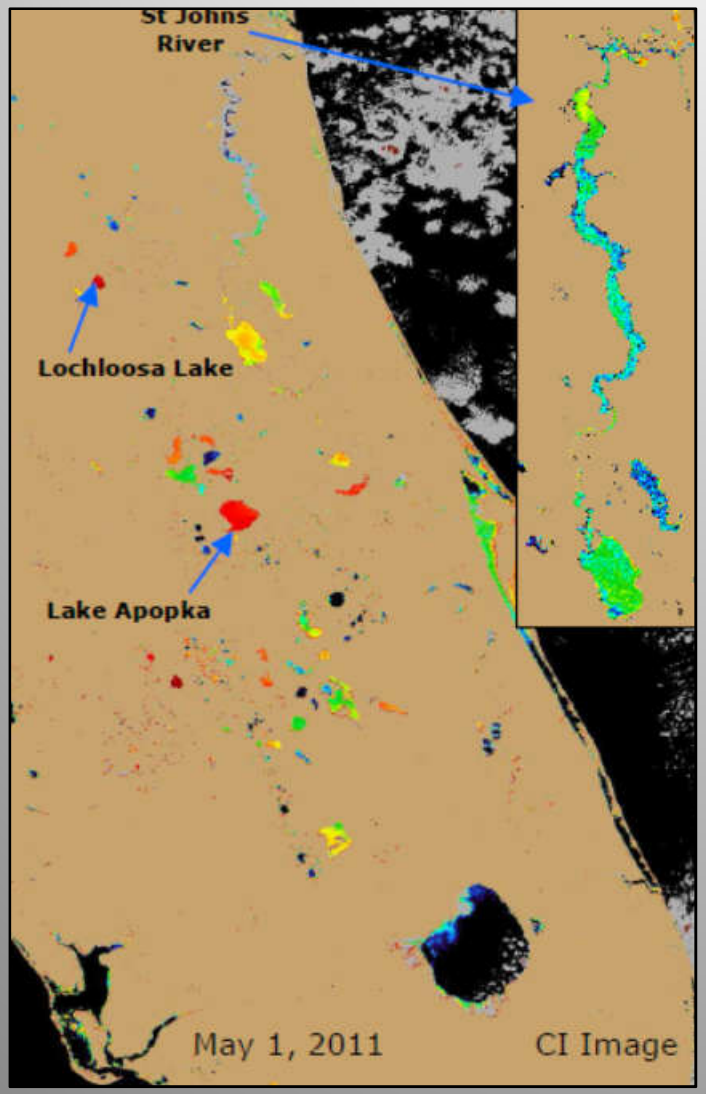


Florida to assess Lake Okeechobee discharges' damage to businesses

Sentinel 3


Ocean and Land Colour Instrument
Microwave Radiometer
Solar Panel
Sea and Land Surface Temperature Radiometer
X-band Antenna
Laser Retro-Reflector
DORIS Antenna
S-band Antenna
SAR Radar Altimeter

High Definition Satellite Imagery

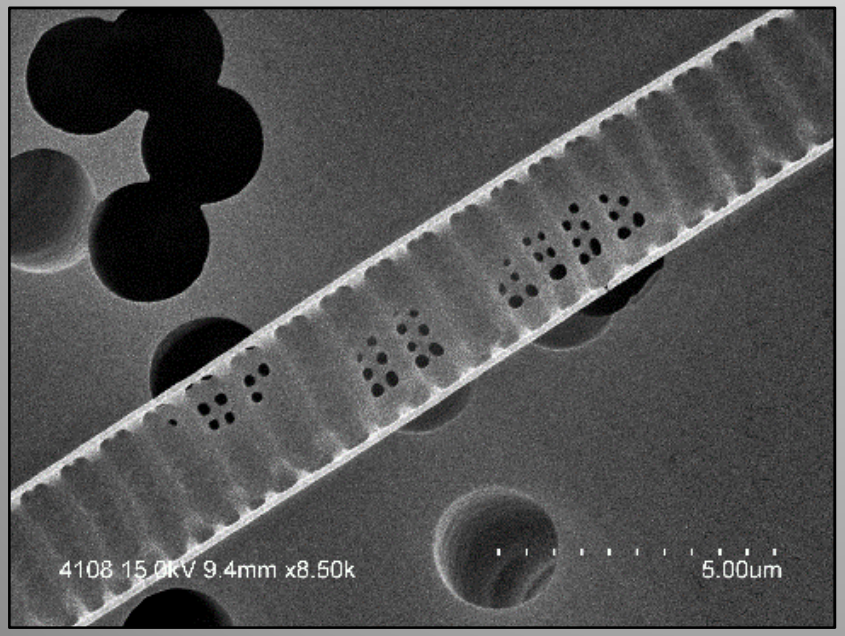


- MERIS European Space Agency

Florida HEALTH

Emerging HAB Threats

- *Pseudo-nitzschia*
  - ✓ *Domoic Acid (DA)*
  - ✓ *Amnesiac Shellfish Poisoning*



https://www.youtube.com/watch?v=Rk-A4vo3TxA

Emerging HAB Threats

- *Pseudo-nitzschia*

PRECAUTIONAY CLOSURE STATEMENT

Date: **Wednesday June 11, 2014**

The Florida Department of Agriculture and Consumer Services is temporarily closing the following shellfish area at sunset on **Wednesday June 11, 2014** for the harvest of oysters, clams, and mussels. In this context, shellfish does not include scallops, shrimp, or crabs.

Area(s): **#5402 SARASOTA BAY Shellfish Harvest Area**

Affected Counties: **MANATEE/SARASOTA**

Basis for action: **Precautionary emergency closure due to presence of Pseudo-Nitsu**

CLOSURE STATEMENT

Date: 10/22/14

The Florida Department of Agriculture and Consumer Services is temporarily closing the following shellfish area at sunset on 10/22/14 for the h
In this context, shellfish does not include scallops, shri

Area(s): **#1401 St. Joe Bay Shellf**

Affected Counties: **Gulf**

Basis for action: **Presence of Pseudo-nitzsch defined in Chapter 5L-1.0**

PRECAUTIONARY CLOSURE STATEMENT

Date: **5/25/16**

The Florida Department of Agriculture and Consumer Services is temporarily closing the following shellfish area at sunset on **Wednesday May 25, 2016** for the harvest of oysters, clams, and mussels. In this context, shellfish does not include scallops, shrimp, or crabs.

Area(s): **#1401 St. Joe Bay Shellfish Harvest Area**

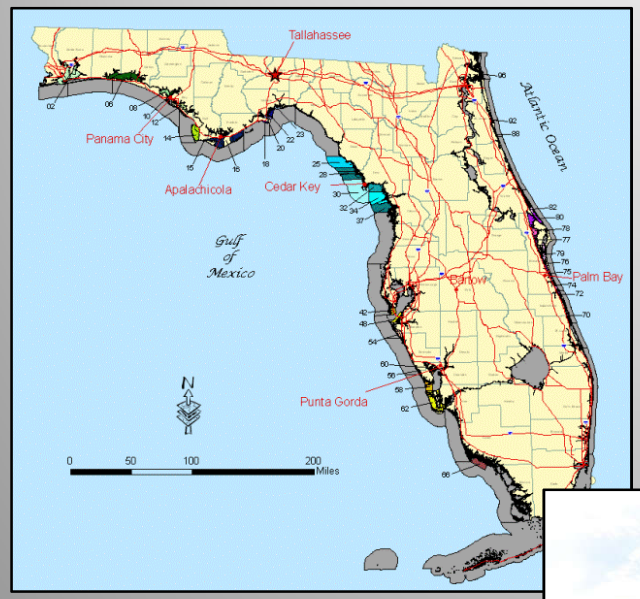
Affected Counties: **Gulf**

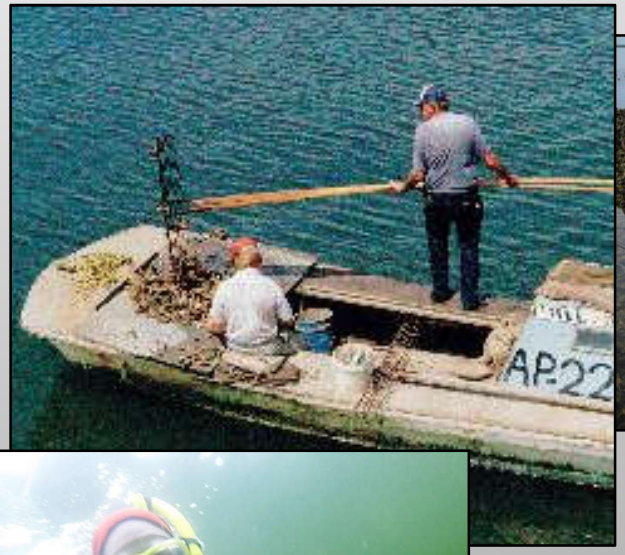
Basis for action: **Precautionary closure due to presence of Pseudo nitzschia and conditions defined in Chapter 5L-1.003 (8), Florida Administrative Code and The Biotoxin Contigency Plan.**

Division of Aquaculture

Emerging HAB Threats

- *Pseudo-nitzschia*





Florida HEALTH

Emerging HAB Threats

- *Pseudo-nitzschia*

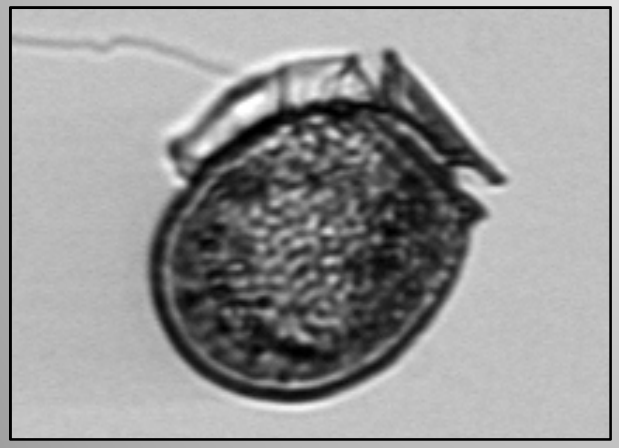
- ✓ Anchovies or sardines contaminated with pseudo-nitzschia, which produces the brain-damaging neurotoxin.
- ✓ Sea lions, suffering from domoic acid poisoning, are dazed, confused and suffering from seizures.

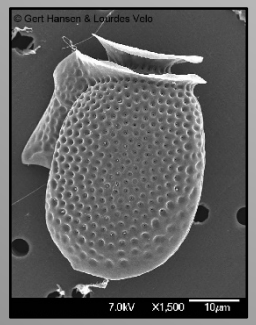
http://ktla.com/2016/03/14/sea-lion-pup-rescued-after-wandering-into-fish-market-parking-lot-in-san-diego/?iframe=true&preview=true

Florida HEALTH

Emerging HAB Threats

- *Dinophysis*
  - ✓ *Domoic Acid (DA)*
  - ✓ *Amnesiac Shellfish Poisoning*
  - ✓ *Not documented in Florida*





https://www.youtube.com/watch?v=196tFAIHpXw

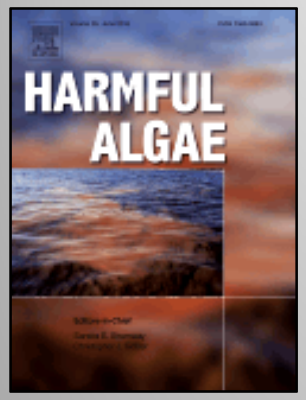
Emerging HAB Threats

- Diverse taxa of cyanobacteria
  - ✓ Beta-methylamino-L-alanine (BMAA)
  - ✓ Amyotrophic lateral sclerosis/ parkinsonism-dementia complex ??

Guam

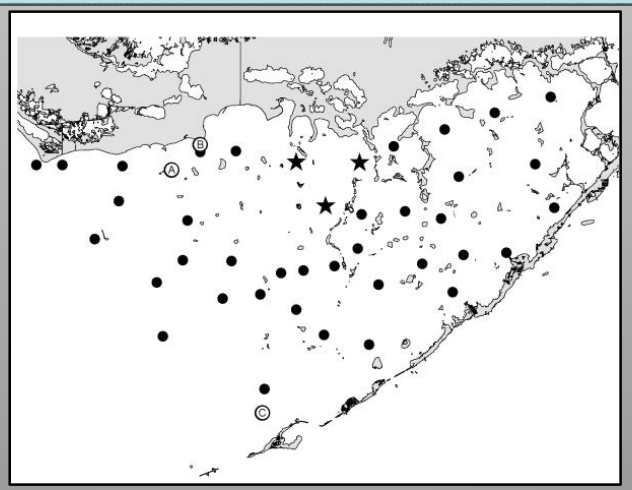
“Chamorro” people

Emerging HAB Threats



- 2010: *Cyanobacterial Blooms and the Occurrence of the neurotoxin … BMAA in South Florida Aquatic Food Webs*

✓ "… most cyanobacteria produce … BMAA"
L. Brand et al.

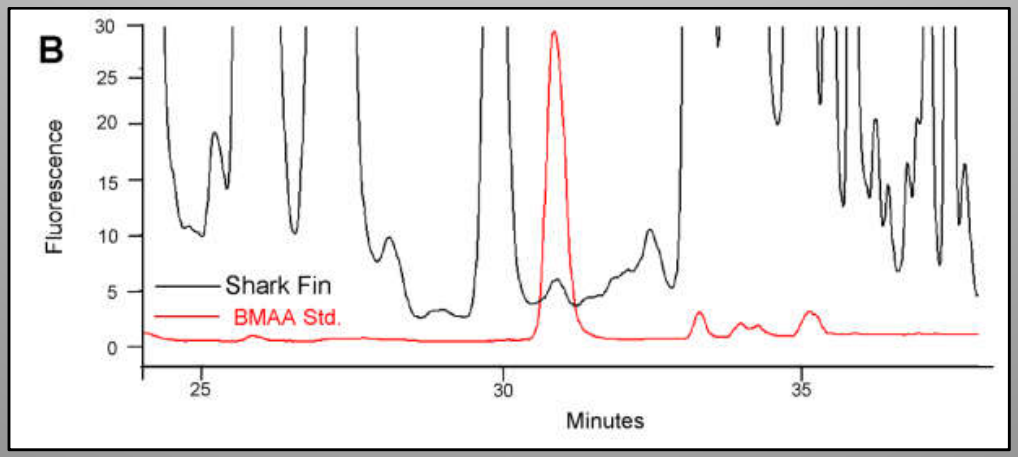


Florida HEALTH

Emerging HAB Threats

- BMAA

- ✓ Little consensus of its ubiquitous occurrence
- ✓ Uncertainty on concentrations reported
- ✓ Problems with replication of study findings
- ✓ Analytical methodology variable



Emerging HAB Threats

- Zoanthids

✓ Palytoxin: *Limu-make-o-Hana*

✓ “ The toxic seaweed of Hana ”

Cyanobacteria Tracking Module

- Florida Department of Health online tracking module for coordinating statewide cyanobacteria bloom response.
  - ✓ Multi-user capability
  - ✓ User name/password protected
  - ✓ Somewhat “development” friendly
  - ✓ Redacted public portal also available

Florida HEALTH

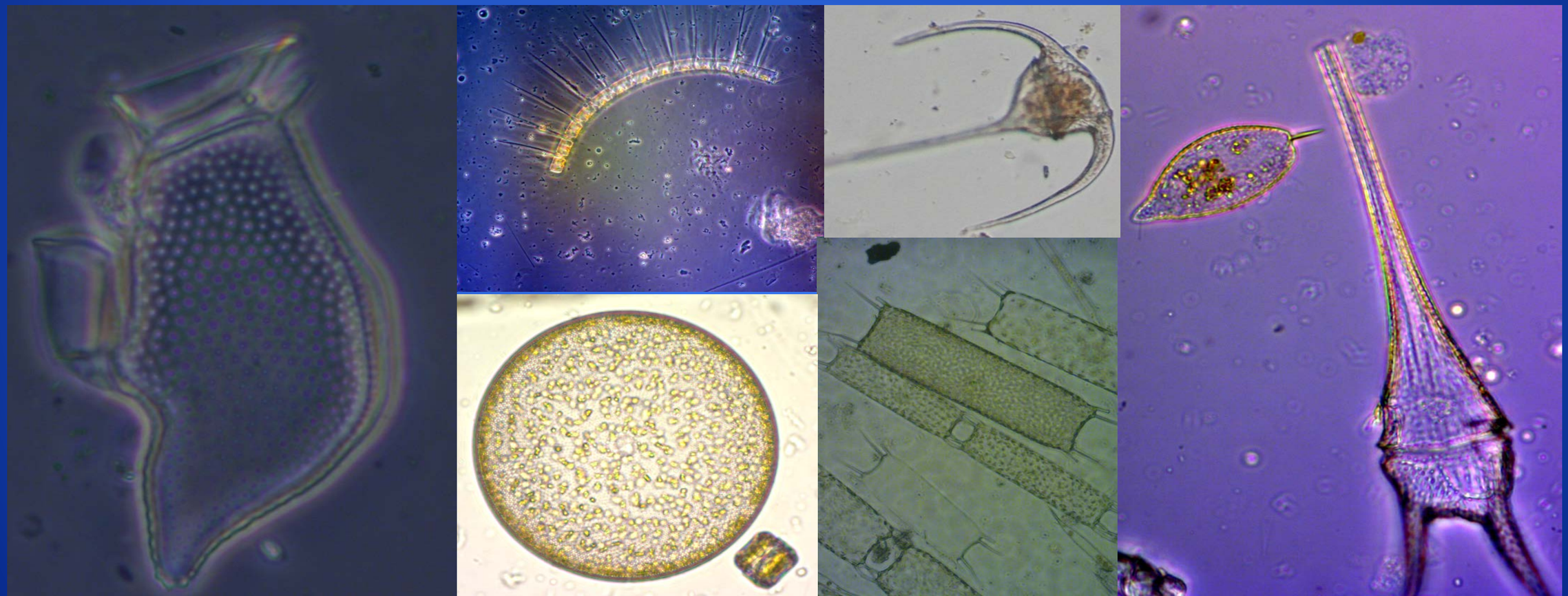
Contact Information

Andrew Reich MS, MSPH, RRT
andy.reich@flhealth.gov
(813) 307-8015 x 5961

www.floridahealth.gov/environmental-health/

ENHANCE ★ PROTECT ★ CONSERVE

Mississippi Department of Marine Resources
Marine Biotoxin Contingency Plan
Kristina Broussard



Marine Biotoxin Contingency Plan

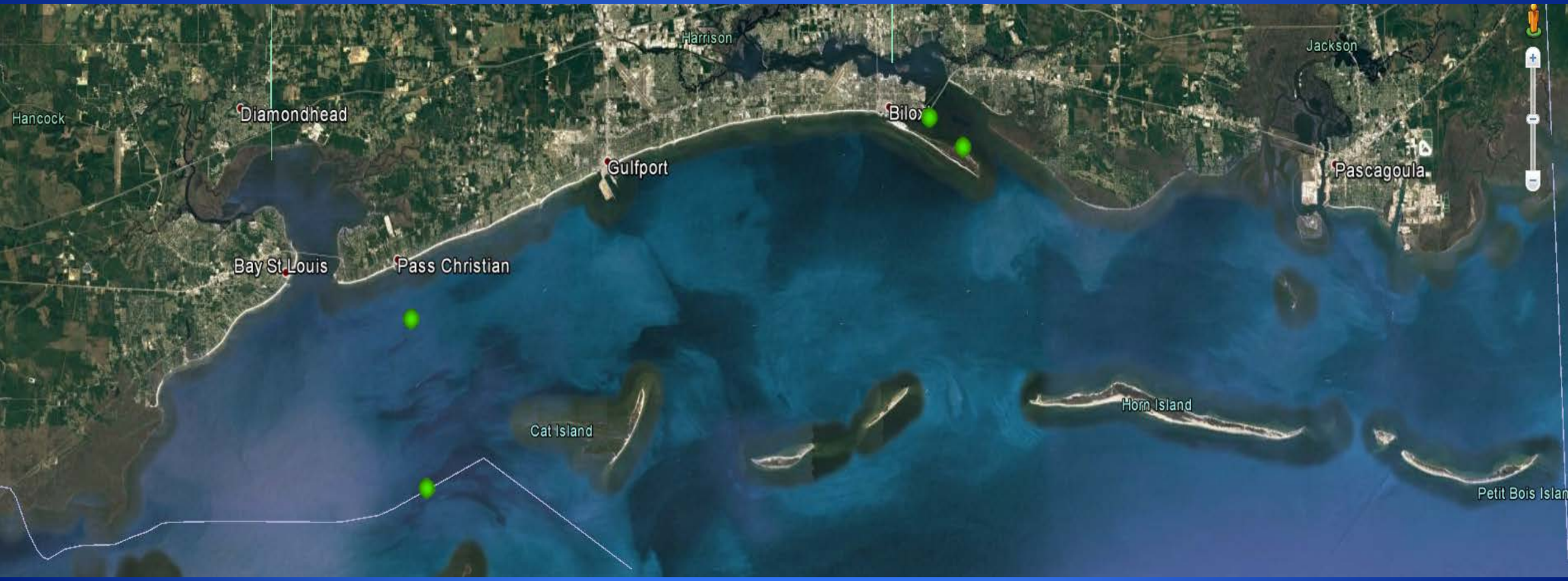
- Developed in 2007
- Revised in 2012 and 2016
- Defines the MDMR Marine Fisheries harmful algal bloom (HAB) monitoring program

Marine Biotoxin Contingency Plan

- MDMR personnel collect water samples twice per month during oyster season (usually October to April) from two sample stations in the western MS Sound and two sample stations in Biloxi Bay.
  - Use of a 20µm plankton net
  - 3 minute tow
- Concentrated samples are examined for the presence of toxic or harmful algal blooms
- Cell counts are only conducted when a toxic algae is present in numbers causing concern to public health

ENHANCE ★ PROTECT ★ CONSERVE

Bimonthly Sample Locations



Marine Biotoxin Contingency Plan

Additional Monitoring:

- MDMR personnel conduct field observations for water discoloration during routine sampling
- Flights over shellfish growing areas are conducted as necessary for observation of water discoloration
- MDMR personnel investigate possible toxic blooms reported by credible sources primarily: adjacent state agencies, federal agencies, local health agencies, and academic institutions.

ENHANCE ★ PROTECT ★ CONSERVE

Marine Biotoxin Contingency Plan

Shellfish growing areas are immediately closed when marine biotoxin producing organisms are present in numbers sufficient to cause a public health risk

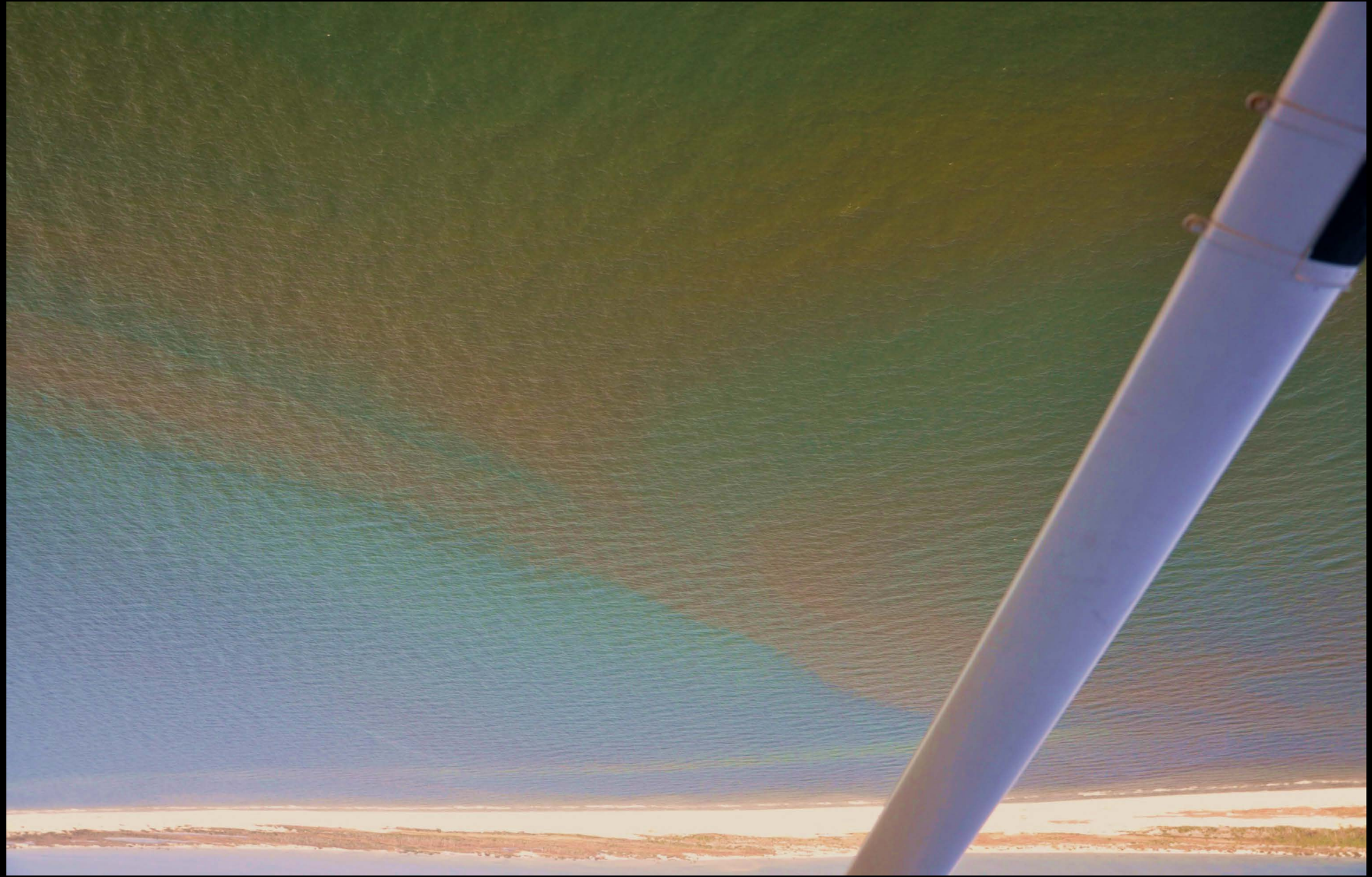
- Identification of a *Karenia brevis* bloom exceeding 5,000 cells/L will trigger an immediate closure of oyster growing areas
- In the event of a bloom from any other biotoxin-producing organisms, technical assistance from FDA and others will be sought in determining closing criteria

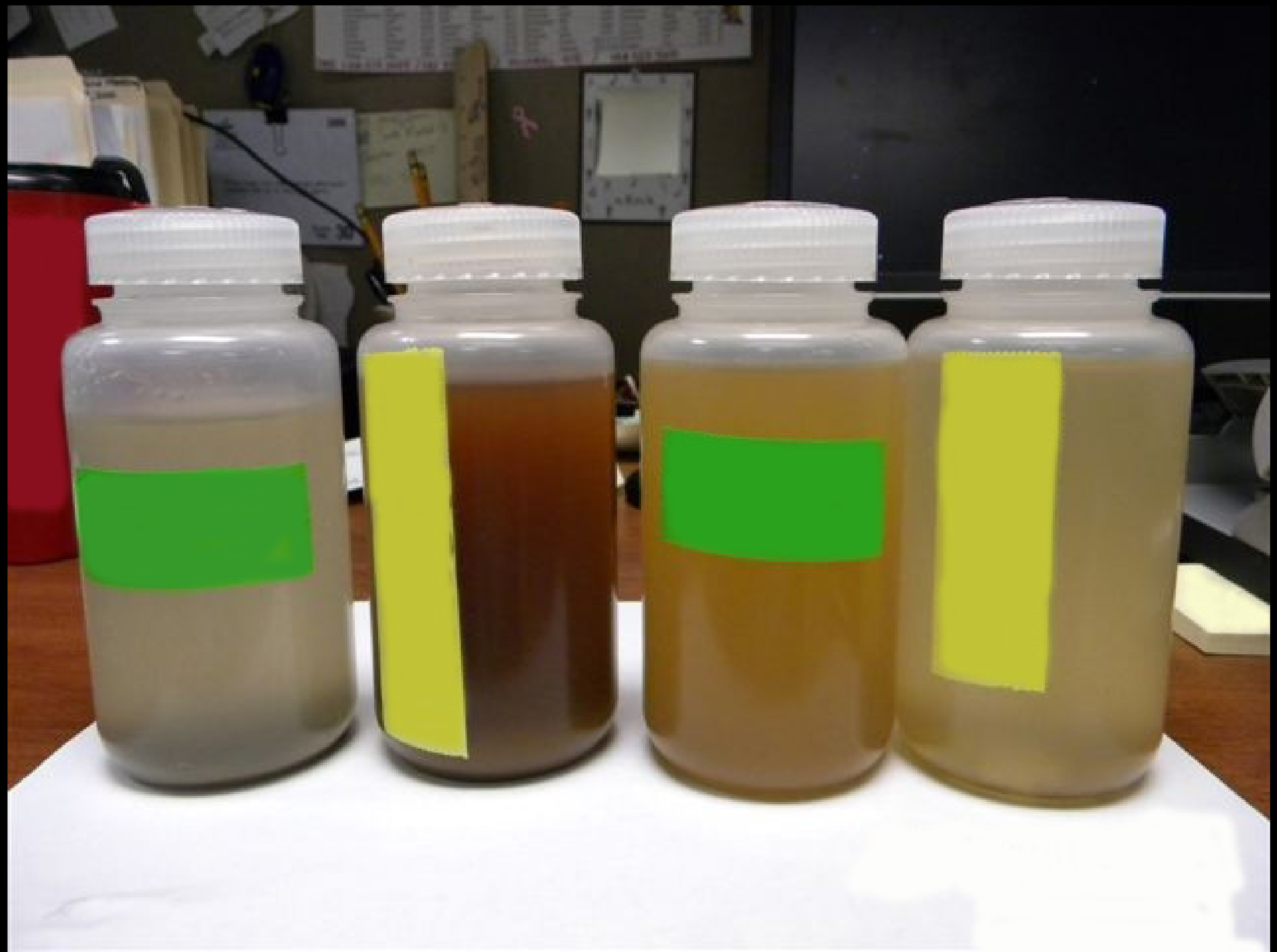
ENHANCE ★ PROTECT ★ CONSERVE

Red tide of *Karenia brevis*

December 1, 2015 – January 6, 2016

Lasted 37 days

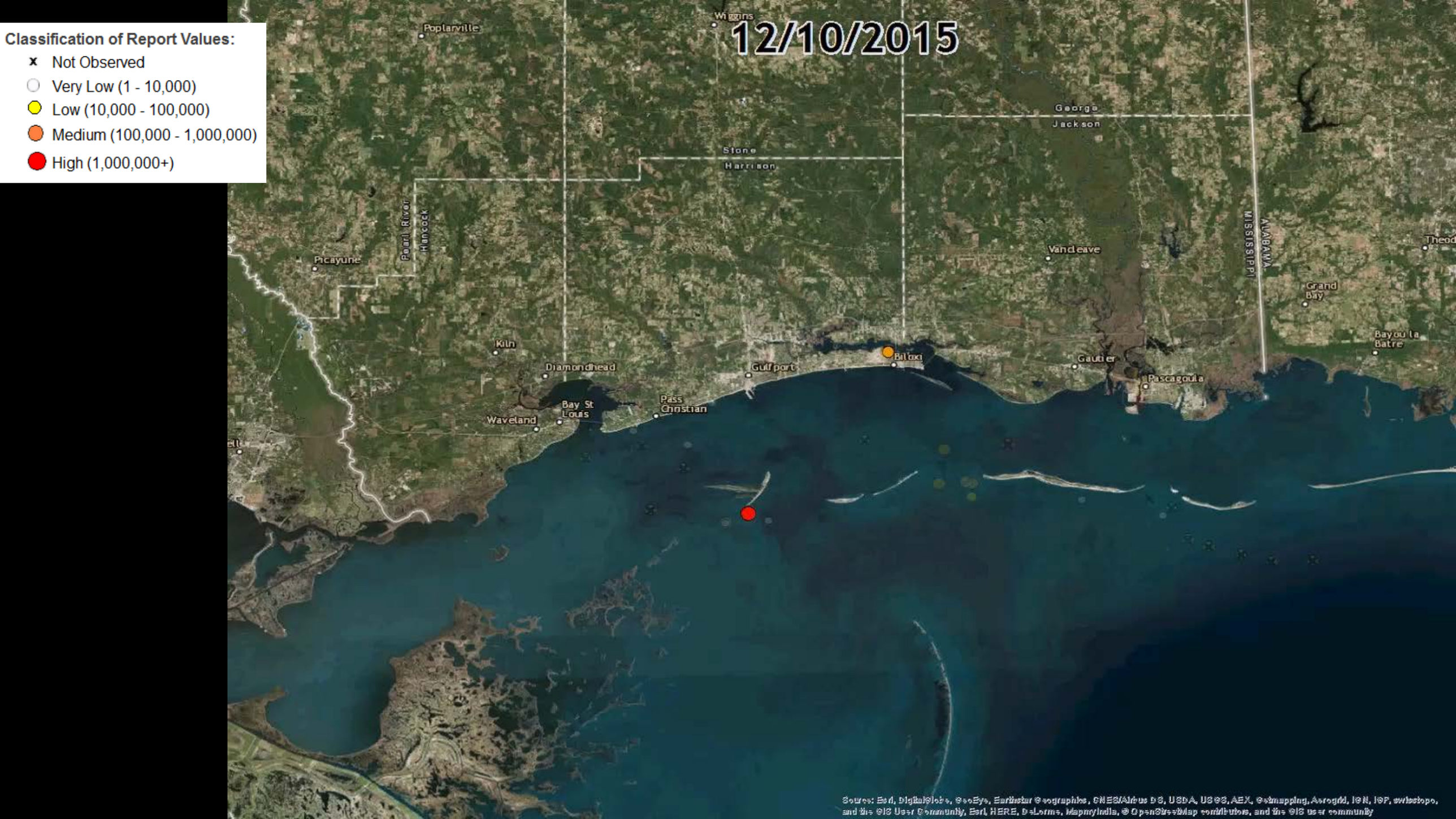




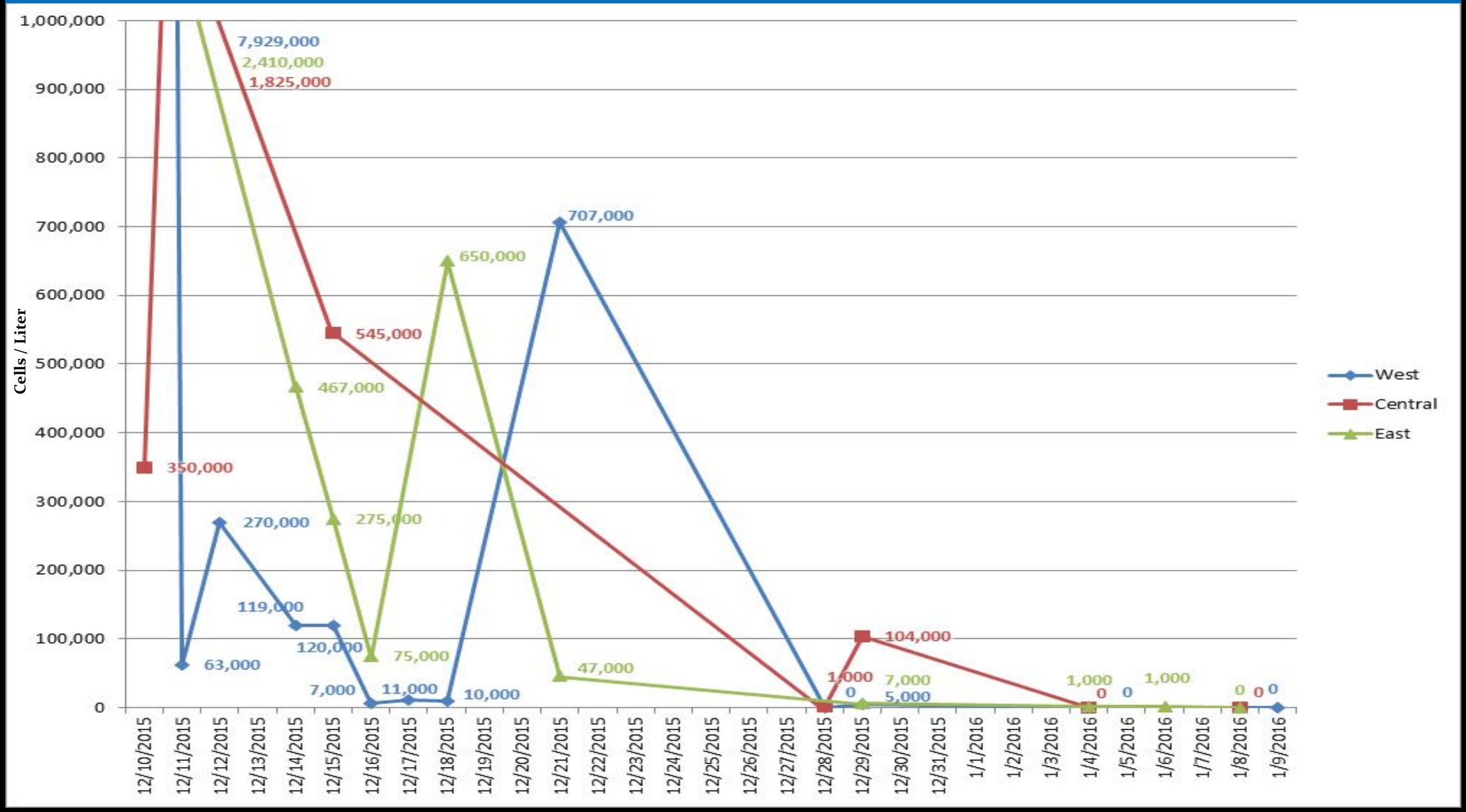
ENHANCE ★ PROTECT ★ CONSERVE

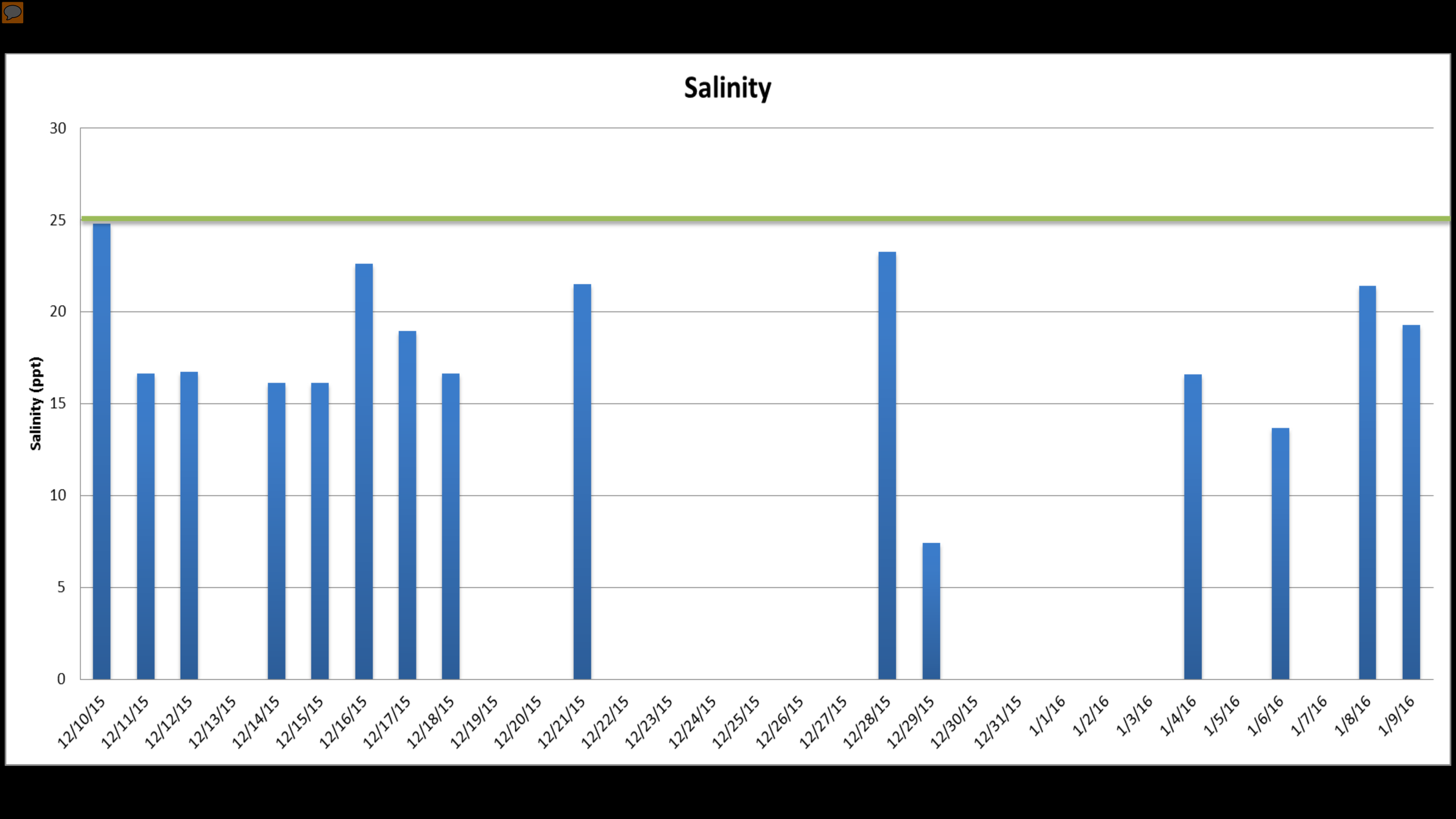
Karenia brevis Bloom December 2015 to January 2016

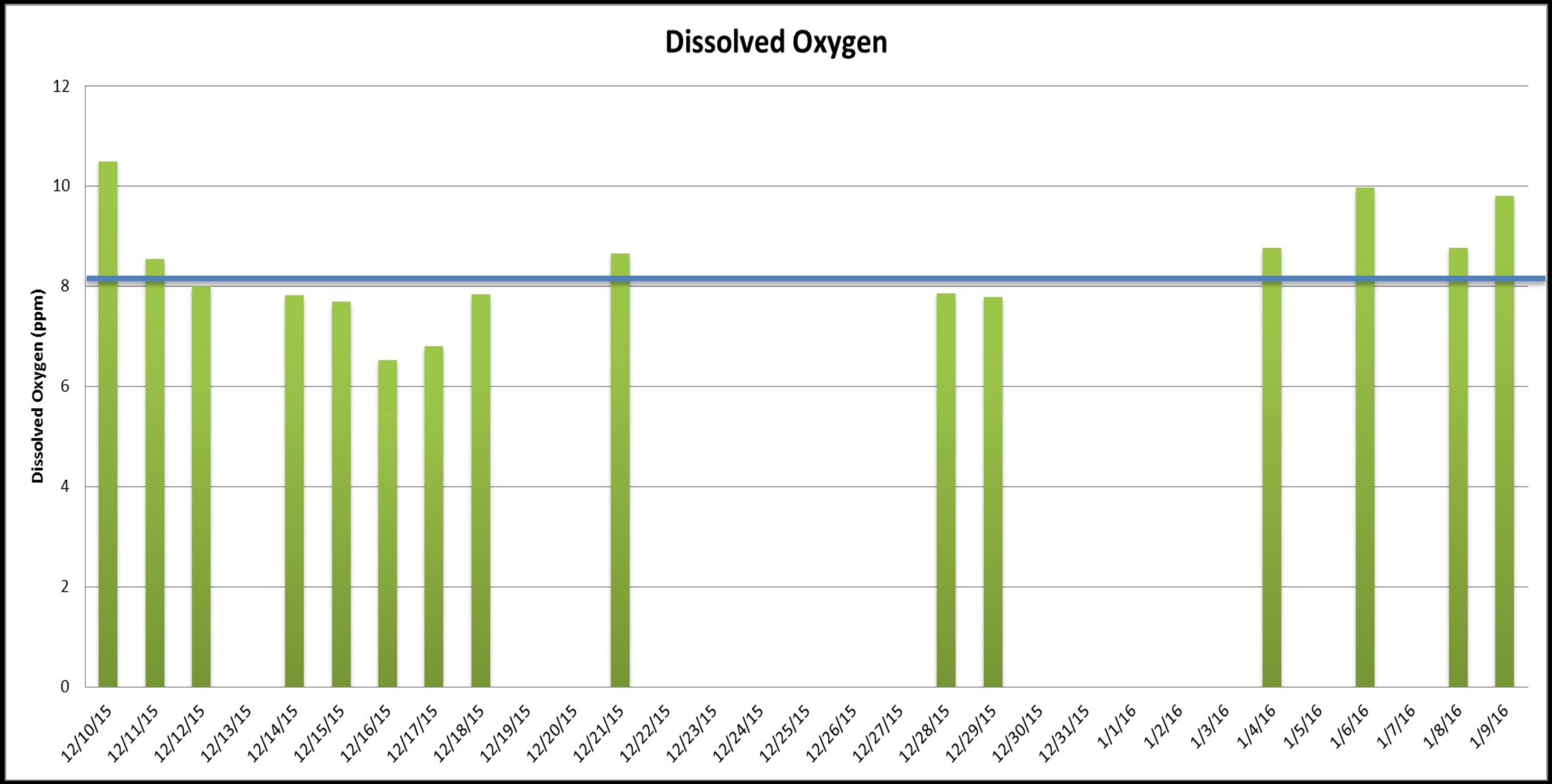
- 263 Samples collected (165 whole water/cell counts & 98 net tows)
- Starting looking on November 10th – received word from AL state authorities that cell counts were high in their area.
- First siting of the *Karenia brevis* bloom in MS waters was December 1st
  - Starting conducting cell counts on samples December 10th
- Last siting of *Karenia brevis* was January 6th
  - 3 coast wide samples showed no presence from January 6th to January 9th

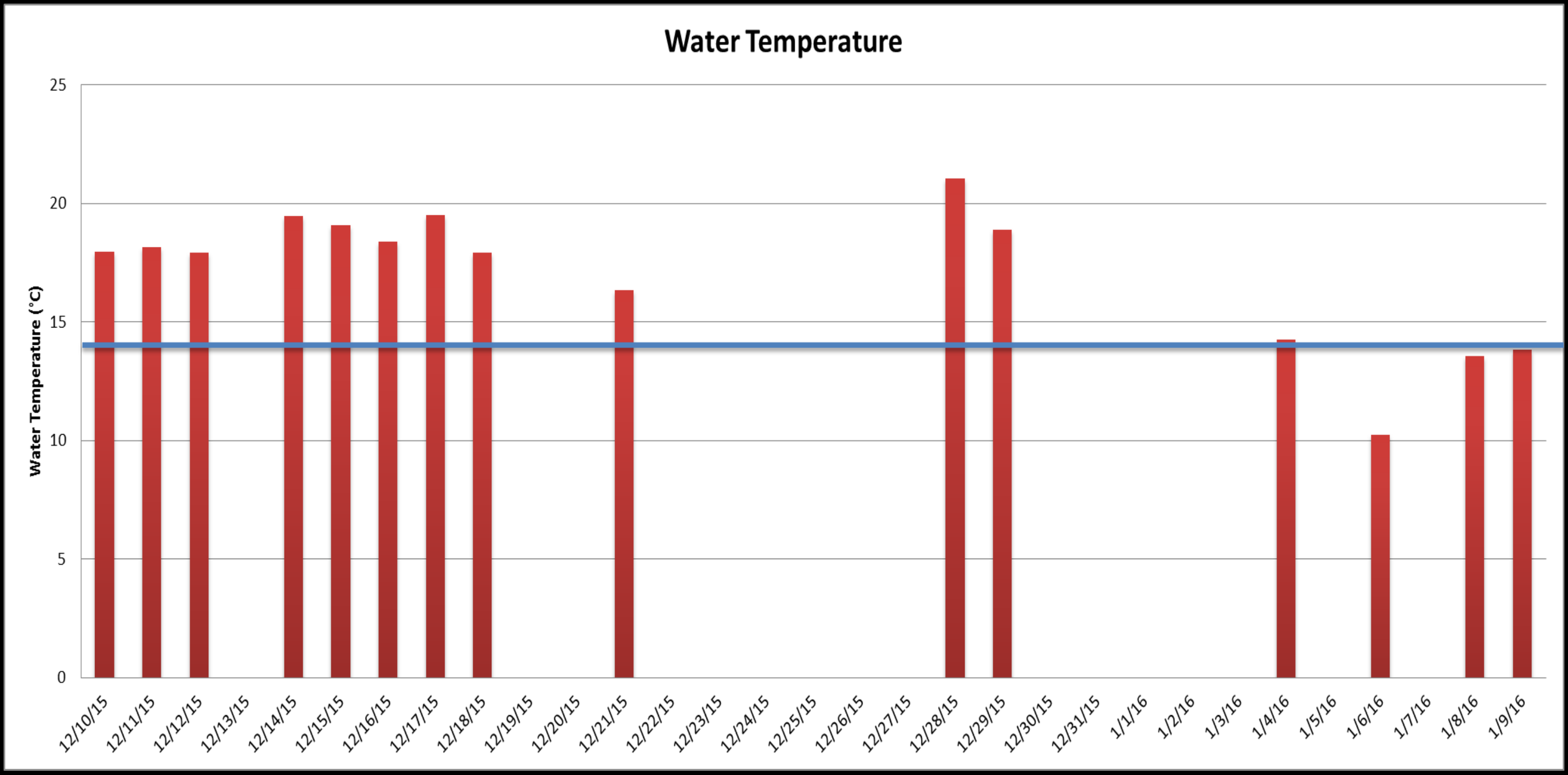

Classification of Report Values:
Not Observed
Very Low (1 - 10,000)
Low (10,000 - 100,000)
Medium (100,000 - 1,000,000)
High (1,000,000+)
12/10/2015
Wiggins
Poplarville
George
Jackson
Stone
Harrison
Pearl River
Hancock
Picayune
Vancleave
MISSISSIPPI
ALABAMA
Grand Bay
Bayou la Batre
Kiln
Diamondhead
Gulfport
Biloxi
Gautier
Pascagoula
Bay St Louis
Pass Christian
Waveland
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

Cell Counts of *Karenia brevis*




Salinity
Salinity (ppt)
30
25
20
15
10
5
0
12/10/15
12/11/15
12/12/15
12/13/15
12/14/15
12/15/15
12/16/15
12/17/15
12/18/15
12/19/15
12/20/15
12/21/15
12/22/15
12/23/15
12/24/15
12/25/15
12/26/15
12/27/15
12/28/15
12/29/15
12/30/15
12/31/15
1/1/16
1/2/16
1/3/16
1/4/16
1/5/16
1/6/16
1/7/16
1/8/16
1/9/16


Dissolved Oxygen
Dissolved Oxygen (ppm)
12
10
8
6
4
2
0
12/10/15
12/11/15
12/12/15
12/13/15
12/14/15
12/15/15
12/16/15
12/17/15
12/18/15
12/19/15
12/20/15
12/21/15
12/22/15
12/23/15
12/24/15
12/25/15
12/26/15
12/27/15
12/28/15
12/29/15
12/30/15
12/31/15
1/1/16
1/2/16
1/3/16
1/4/16
1/5/16
1/6/16
1/7/16
1/8/16
1/9/16


Water Temperature
Water Temperature (°C)
25
20
15
10
5
0
12/10/15
12/11/15
12/12/15
12/13/15
12/14/15
12/15/15
12/16/15
12/17/15
12/18/15
12/19/15
12/20/15
12/21/15
12/22/15
12/23/15
12/24/15
12/25/15
12/26/15
12/27/15
12/28/15
12/29/15
12/30/15
12/31/15
1/1/16
1/2/16
1/3/16
1/4/16
1/5/16
1/6/16
1/7/16
1/8/16
1/9/16

ENHANCE ★ PROTECT ★ CONSERVE

Karenia brevis Bloom December 2015 to January 2016

- ELISA Test
  - Enzyme-Linked Immunosorbant Assay (ELISA) test was used to pre-screen samples for the presence or absence of brevetoxins.
  - Conducted by the Dauphin Island Sea Lab, AL on January 13th
  - 7 Samples
    - Pass Christian Dredging and Tonging Reefs, Pass Marianne Reef, St Joe Reef, St Stanislaus Reef, Between the Bridges, Henderson Point Reef
  - Oyster batches from each area sampled were determined to contain brevetoxin-3 equivalent levels **well below the FDA guidance level of 800 ppb** .

ENHANCE ★ PROTECT ★ CONSERVE

Karenia brevis Bloom December 2015 to January 2016

- Mouse Bioassay
  - Neurotoxic Shellfish Poisoning Bioassay
  - Florida Fish and Wildlife Conservation Commission, St Petersburg, FL received and extracted the samples –
    - The biotoxin laboratory at FWRI is the official state laboratory of Florida for testing algal toxins in shellfish following harvesting bans caused by red tide.
  - Resource Access International, Brunswick, Maine completed the bioassay
  - 6 Samples
    - Pass Christian Dredging and Tonging Reefs, St Joe Reef, St Stanislaus Reef, Between the Bridges, Henderson Point Reef
  - All of the mice survived the bioassay test. All tests were less than 20 Mouse Units (MU) /100 grams.

ENHANCE ★ PROTECT ★ CONSERVE

Karenia brevis Bloom December 2015 to January 2016

- FDA ISSC NSSP Model Ordinance Section IV Chap. II .03 C.
  - (4) The closed status shall remain in effect until the Authority has data to show that the toxin content of the shellfish in the growing area is below the level established for closing the area.
    - (C)(b) NSP – 5,000 cells/L or 20 MU/100 grams (0.8 mg brevetoxin – 2 equilivants/kg)
    - NSSP Link: https://www.fda.gov/downloads/Food/GuidanceRegulation/FederalStateFoodPrograms/UCM505093.pdf
- Cell Counts, ELISA Test, Mouse Bioassay
  - show low to no levels of brevetoxin present

Shellfish Toxicity

Shellfish Toxicity = why we created the Marine Biotoxin Contingency Plan:

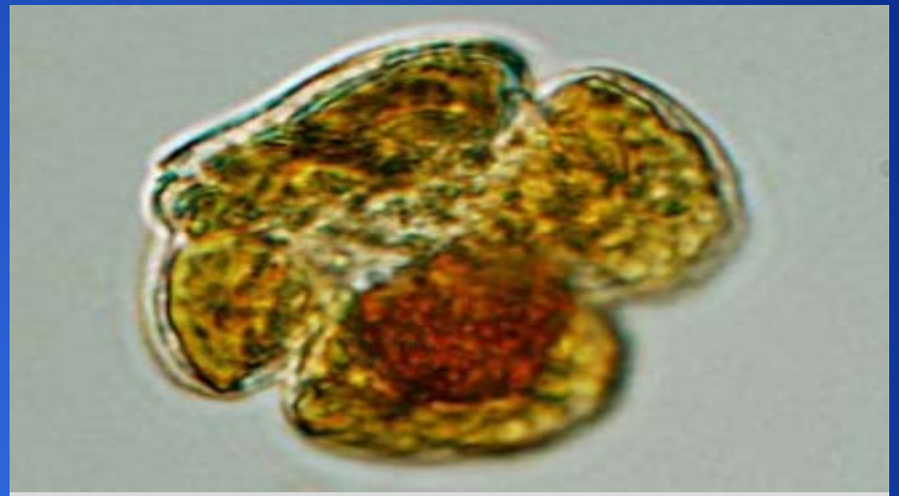
- Neurotoxic Shellfish Poisoning (NSP)
- Amnesic Shellfish Poisoning (ASP)
- Paralytic Shellfish Poisoning (PSP)
- Diarrhetic Shellfish Poisoning (DSP)

ENHANCE ★ PROTECT ★ CONSERVE

Shellfish Toxicity

Neurotoxic Shellfish Poisoning (NSP)

- Toxin = Brevetoxin
- Symptoms include:
  - Nausea & Vomiting
  - Neurologic symptoms such as slurred speech
  - Muscle/Joint pain
  - Difficulty breathing
  - Double vision
- In addition, *Karenia brevis* fish kills and toxic aerosols leading to respiratory irritation



Karenia brevis

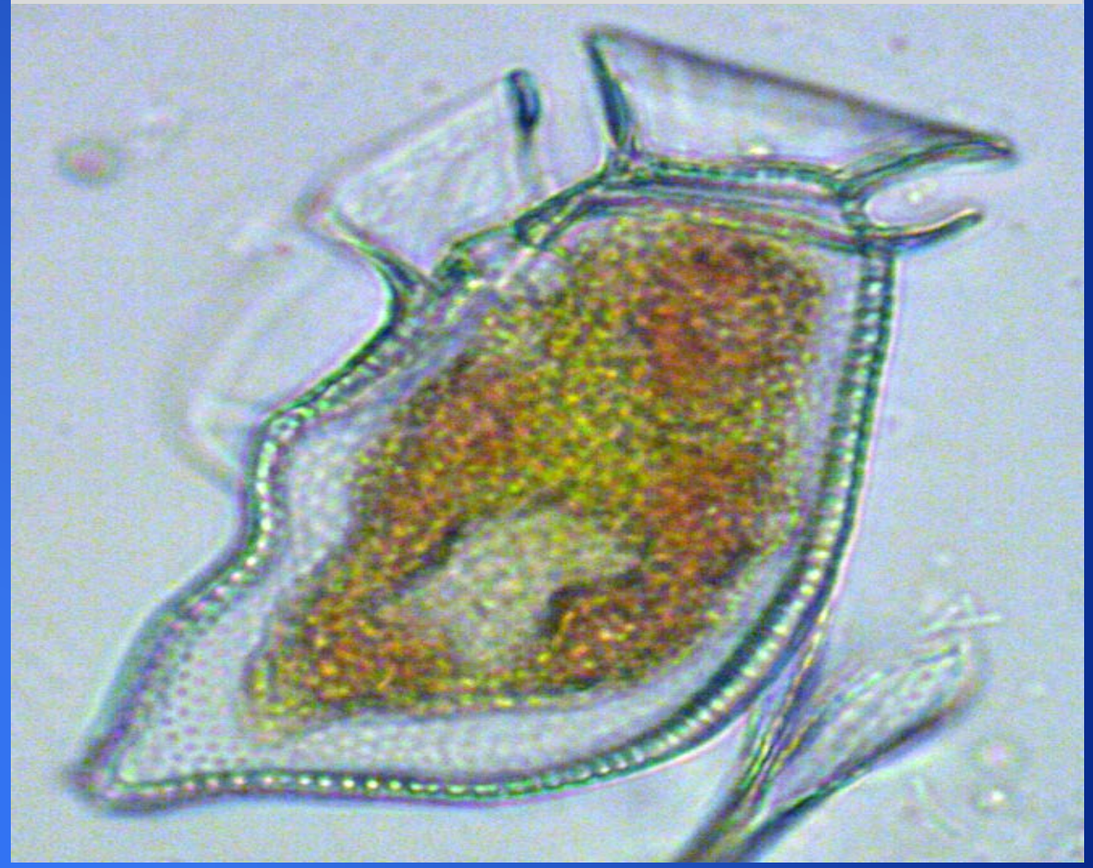
ENHANCE ★ PROTECT ★ CONSERVE

Shellfish Toxicity

Diarrhetic Shellfish Poisoning (DSP)

- Toxin = Okadaic Acid
- Symptoms include:
  - Gastrointestinal problems
  - Nausea
  - Vomiting
  - Abdominal pain
- No neurological effects
- Symptoms occur within 30 minutes after consumption

Dinophysis spp.



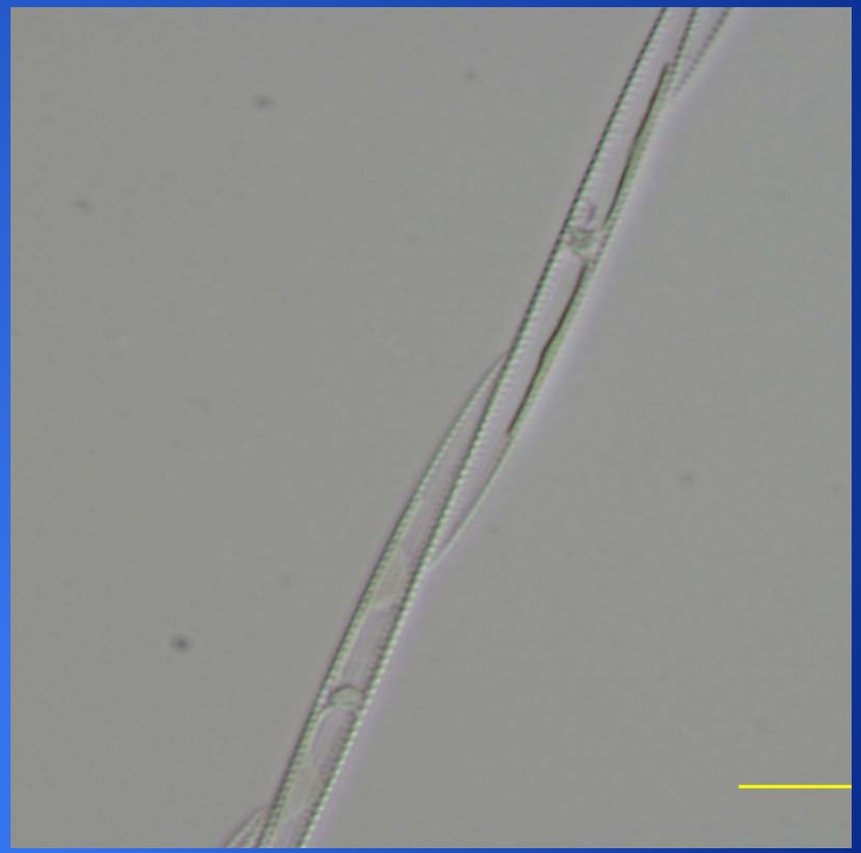
ENHANCE ★ PROTECT ★ CONSERVE

Shellfish Toxicity

Amnesic Shellfish Poisoning (ASP)

- Toxin = Domoic Acid
- Symptoms may range from
  - Gastrointestinal problems
  - Neurological symptoms: headache, dizziness, confusion and disorientation
  - Permanent brain damage (loss of short term memory)
  - Possibly death
- Domoic acid is *NOT* removed by cooking / freezing

Pseudo-nitzschia spp.



ENHANCE ★ PROTECT ★ CONSERVE

Shellfish Toxicity

Paralytic Shellfish Poisoning (PSP)

- Toxin = many toxins combined known as Saxitoxins
- Symptoms include:
  - Numbness
  - Disorientation
  - Paralysis
  - Possibly death by paralysis, mainly of the respiratory system

Alexandrium spp.

Resource Guide for Harmful Algal Bloom Toxin Sampling and Analysis

---

White Paper from the Gulf of Mexico Alliance

Water Quality Priority Issue Team

Harmful Algal Blooms Workgroup

August 2014

White Paper from the Gulf of Mexico Alliance

Water Quality Priority Issue Team

Harmful Algal Blooms Workgroup

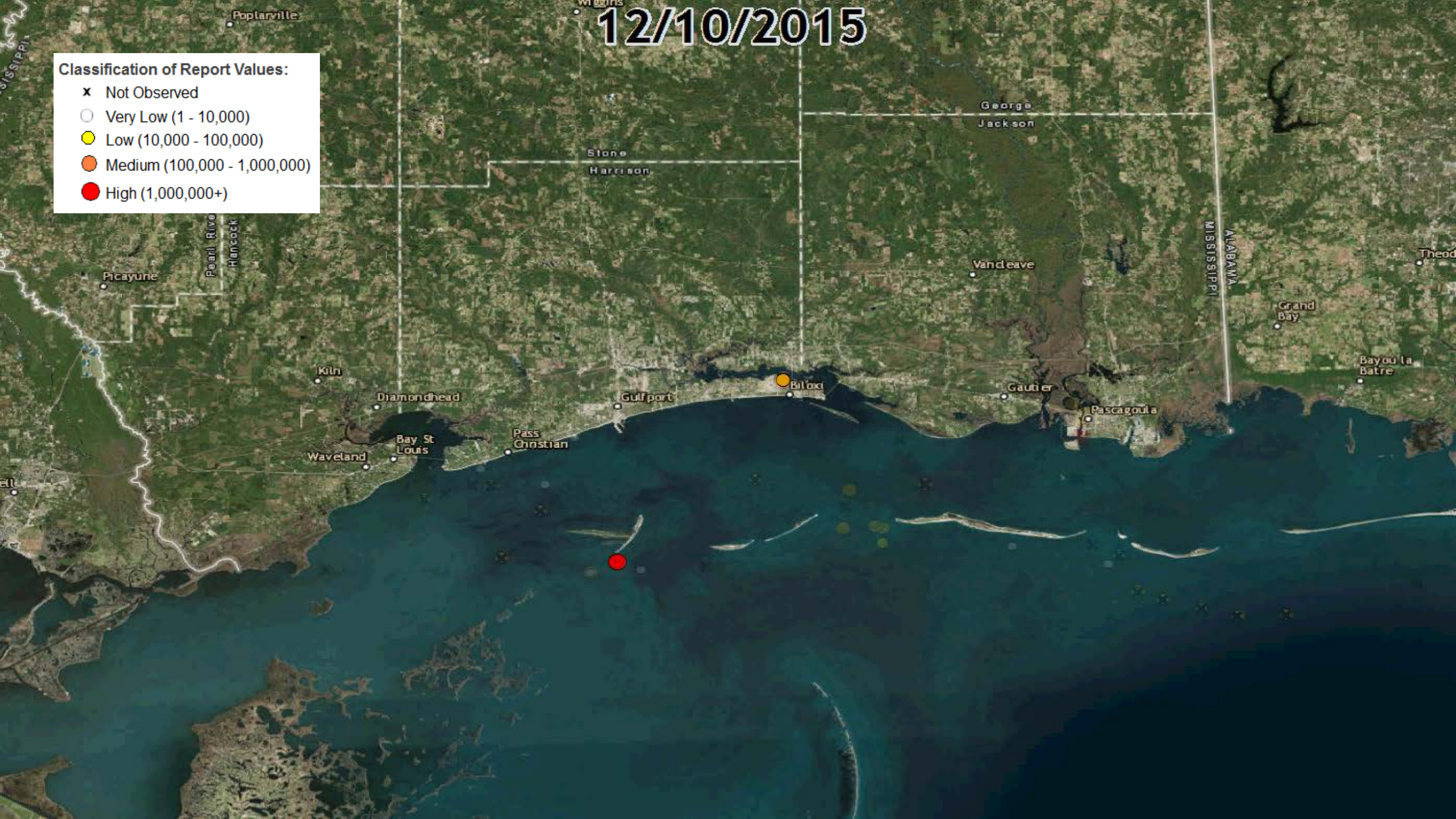
Authors

Alan Lewitus	National Oceanic and Atmospheric Administration
Sibel Bargu	Louisiana State University
Meredith Byrd	Texas Parks and Wildlife Department
Carol Dorsey	Alabama Department of Public Health
Leanne Flewelling	Florida Fish and Wildlife Conservation Commission
Adrienne Flowers	University of Southern Mississippi
Cindy Heil	Bigelow Laboratories for Ocean Sciences
Charles Kovach	University of South Florida
Vince Lovko	Mote Marine Laboratory
Karen Steidinger	Florida Fish and Wildlife Conservation Commission

ENHANCE ★ PROTECT ★ CONSERVE

Thank you

kristina.broussard@dmr.ms.gov


12/10/2015
Classification of Report Values:
Not Observed
Very Low (1 - 10,000)
Low (10,000 - 100,000)
Medium (100,000 - 1,000,000)
High (1,000,000+)
Poplarville
Wiggins
George
Jackson
Stone
Harrison
Pearl River
Hancock
Picayune
Vancleave
MISSISSIPPI
ALABAMA
Grand Bay
Bayou la Batre
Kiln
Diamondhead
Gulfport
Biloxi
Gautier
Pascagoula
Bay St Louis
Pass Christian
Waveland

Applications of Satellite Data to Monitoring and Assessment of Harmful Algal Blooms

Rick Stumpf

National Ocean Service

National Centers for Coastal Ocean Science

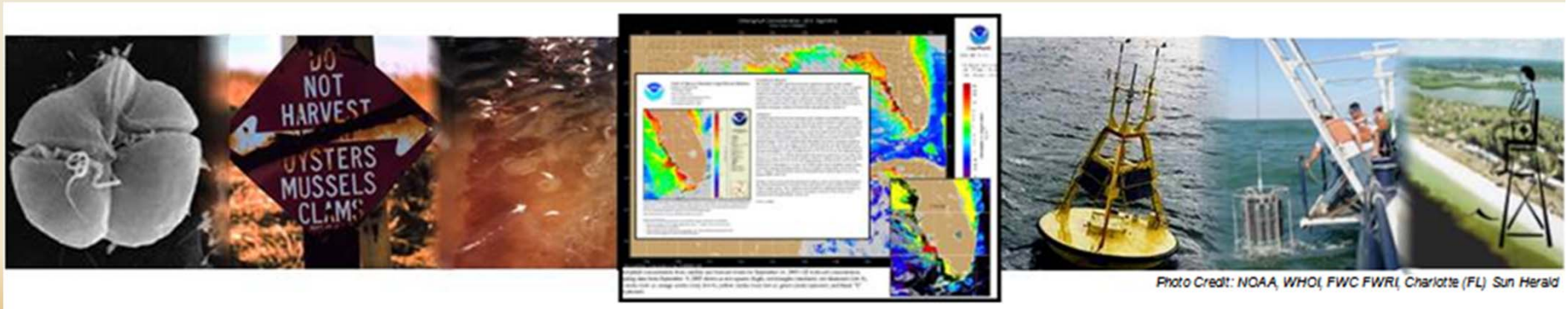
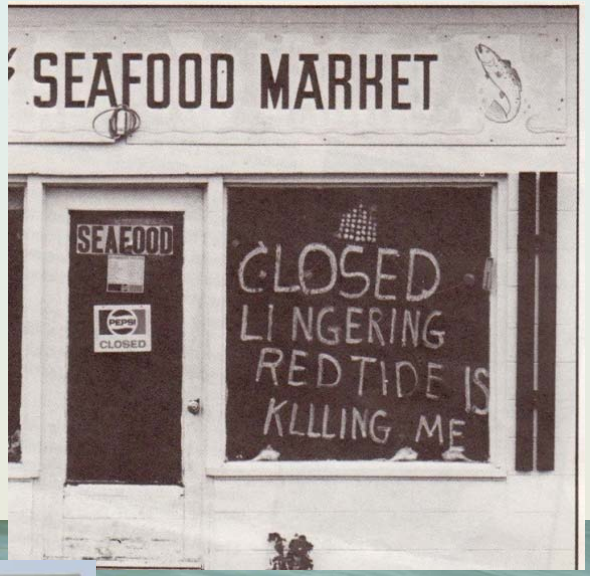
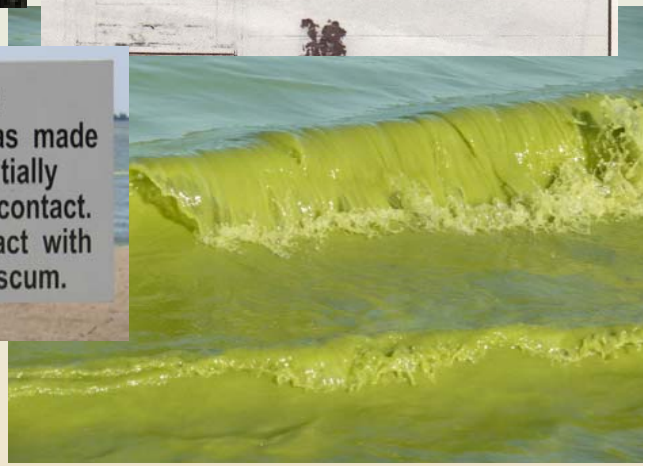


Photo Credit: NOAA, WHOI, FWC FWRI, Charlotte (FL) Sun Herald

Hazards of Harmful Algal Blooms (HABs)

- Shellfish poisoning
- Economic
- Fish kills
- Marine mammals and birds
- Freshwater swimming
- Drinking water
- Clogging desal plants





California sea lion undergoing stomach pumping after poisoning (photo courtesy Dr. Francis Gulland, Marine Mammal Center, Sausalito, CA)

URGENT NOTICE TO RESIDENTS

DO NOT DRINK THE WATER
DO NOT BOIL THE WATER

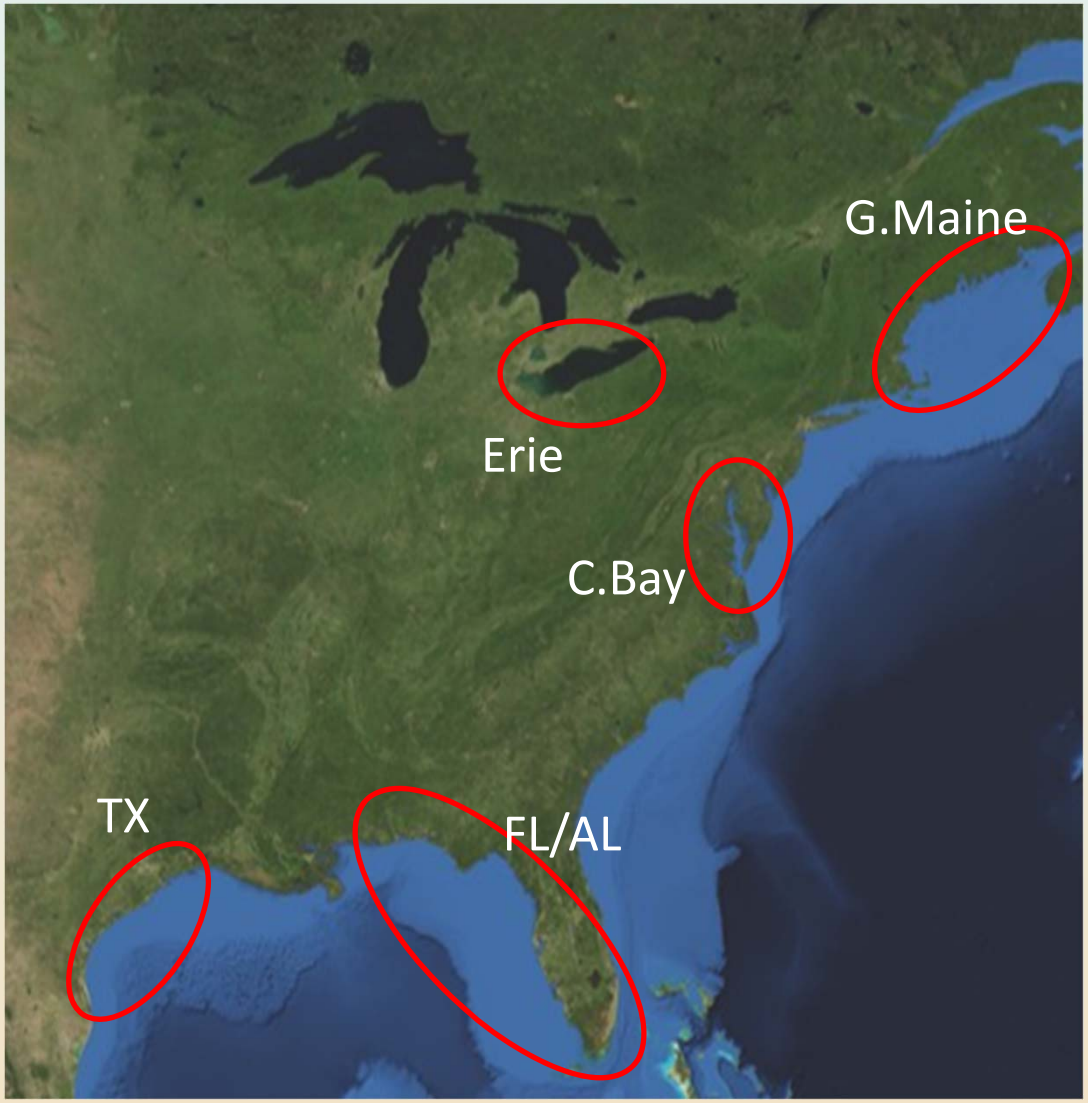
Satellites are part of Forecasting. Why does HAB forecasting matter?

- Toledo, >$2 million economic loss from two-day bloom impact
  - Annually $11M for chemical treatment (nbcnews.com)
  - Methods will help with P reduction targets
- Florida tourism loss, $6M per month per county
  - Health, ER admissions 54% increase in respiratory, 40% increase in gastro-intestinal
- Gulf of Maine halo effect
  - 2005 $10's millions lost seafood

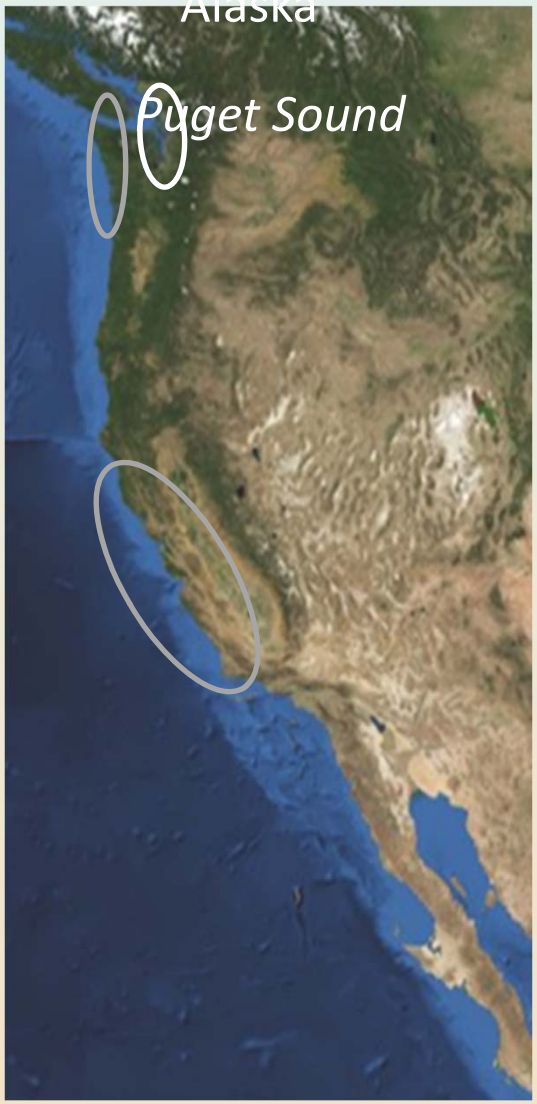
Thick, Putrid Algae Bloom Overwhelms Miles Of Florida Coastline

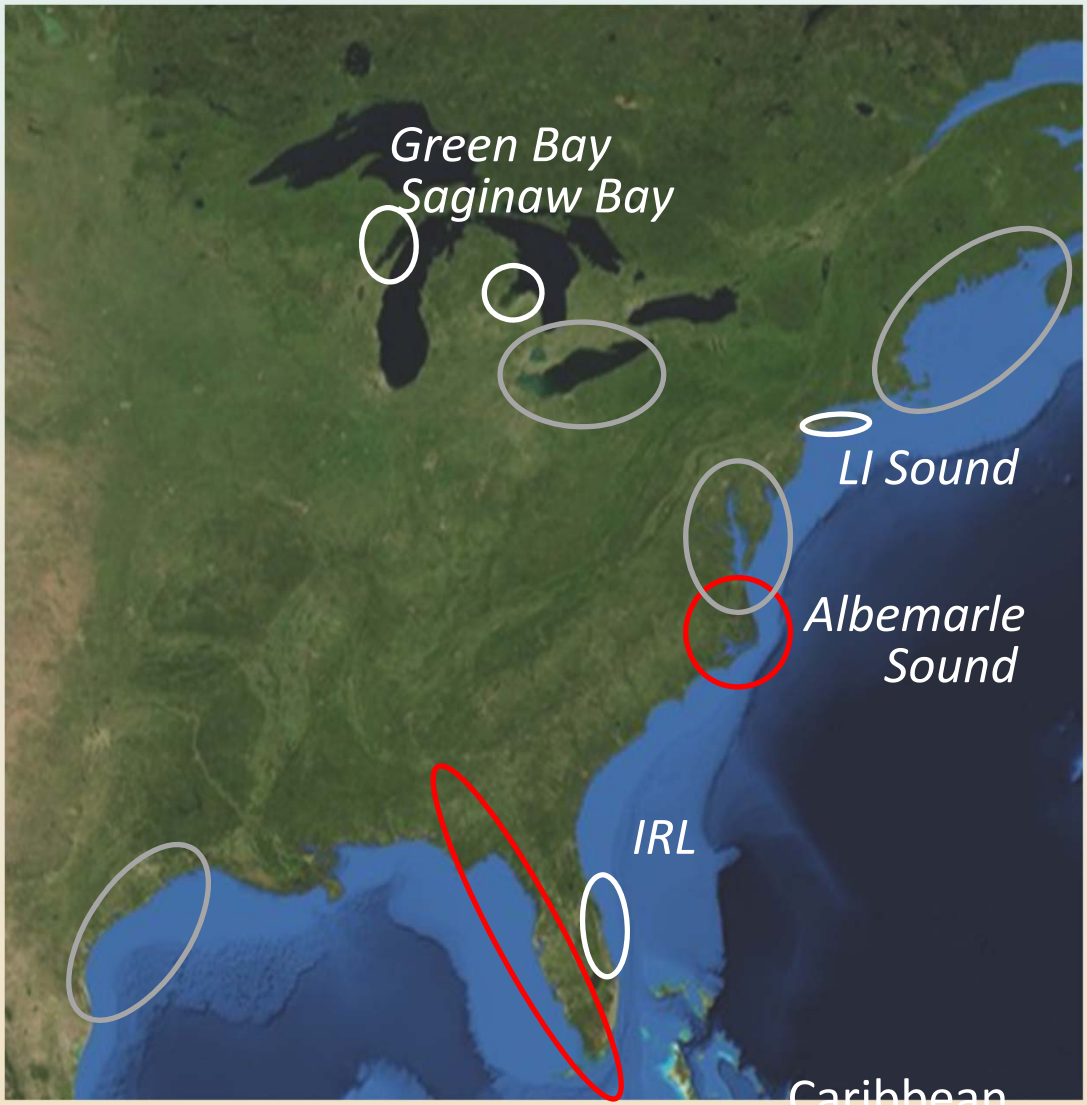
July 2, 2016 · 5:16 PM ET

Some regions with chronic severe HABs
NOAA is working on models, detection, and forecasts



“Emerging” problem areas





Biggest needs for modeling

Initializing operational models, we don't have enough data on bloom location.

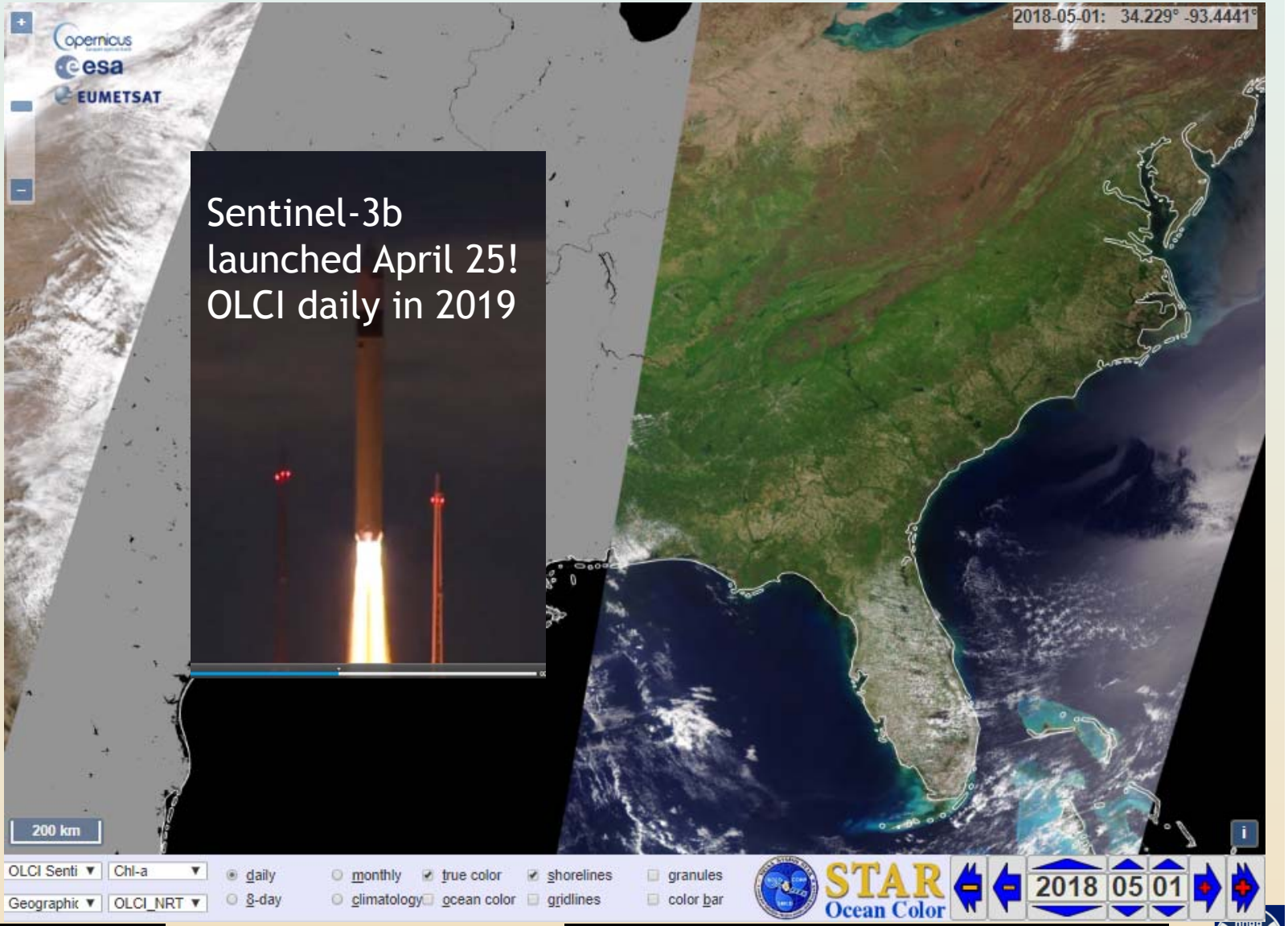
Scenario models, for most areas, insufficient data on initialization.

Validating operational model comparison (is one model "better"), we don't have enough data on bloom location.

Satellite data is a key part to this.

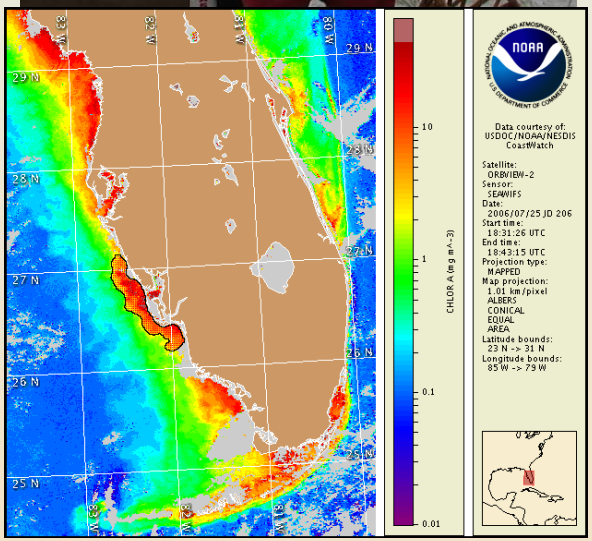
Synoptic, repetitive, and available from past.

Sentinel-3a launch in 2016 now operational, 3-4 scenes per week from OLCI sensor



HAB Operational Forecast System: Gulf of Mexico *Karenia brevis*

Padre Island National Seashore Closes Park to Dogs (December 9, 2009)

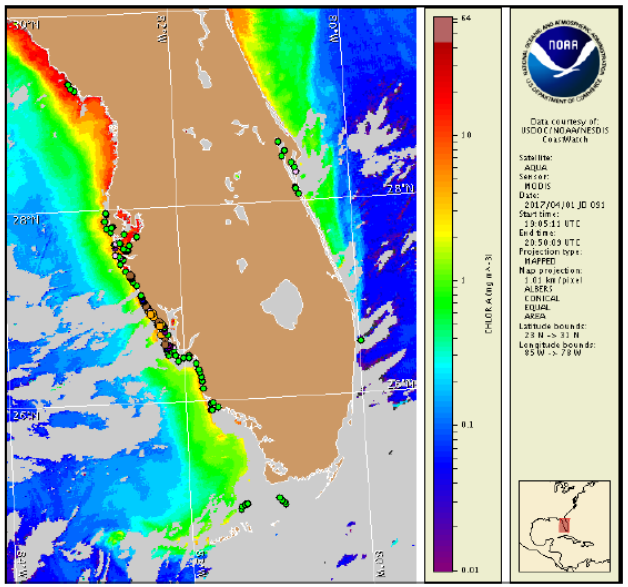


http://tidesandcurrents.noaa.gov/hab

Gulf of Mexico Harmful Algal Bloom Operational Forecast System

Gulf of Mexico Harmful Algal Bloom Bulletin

Region: Southwest Florida
Monday, 03 April 2017
NOAA National Ocean Service
NOAA Satellite and Information Service
NOAA National Weather Service
Last bulletin: Thursday, March 30, 2017



Satellite chlorophyll image with possible *K. brevis* HAB areas shown by red polygon(s), when applicable. Points represent cell concentration sampling data from March 24 to 31: red (high), orange (medium), yello (low b), brown (low a), blue (very low b), purple (very low a), pink (present), and green (not present). Cell count data are provided by Florida Fish and Wildlife Conservation Commission (FWC) Fish and Wildlife Research Institute. For a list of sample providers and a key to the cell concentration categories, please see HAB-OFS bulletin guide:

http://tidesandcurrents.noaa.gov/hab/hab_publication/habfs_bulletin_guide.pdf

Detailed sample information can be obtained through FWC Fish and Wildlife Research Institute at:
http://myfwc.com/redtidestatus

To see previous bulletins and forecasts for other Harmful Algal Bloom Bulletin regions, visit at: http://tidesandcurrents.noaa.gov/hab/bulletins.html

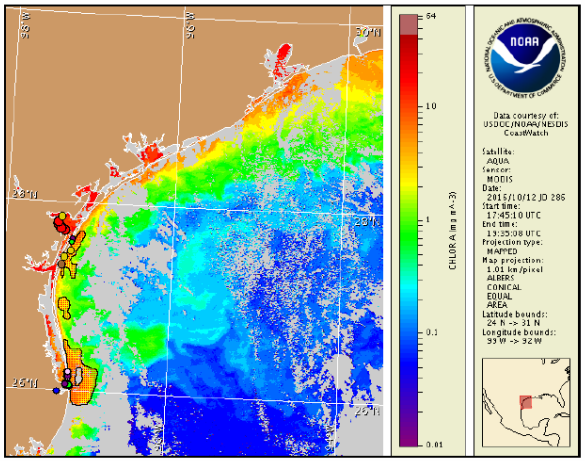
Conditions Report

Not present to medium concentrations of *Karenia brevis* (commonly known as Florida red tide) are present along- and offshore portions of southwest Florida and not present in the Florida Keys. *K. brevis* concentrations are patchy in nature and levels of respiratory irritation will vary locally based upon nearby bloom concentrations, ocean currents, and wind speed and direction. The highest level of potential respiratory irritation forecast for Monday, April 3 through Thursday, April 6 is listed below:

County Region: Forecast (Duration)
Southern Pinellas: Very Low (M-Th)
Southern Manatee: Very Low (M-Th)
Northern Sarasota: Low (M-Th)
Northern Sarasota, bay regions: Low (M-Th)
Southern Sarasota: Moderate (M-Th)
Southern Sarasota, bay regions: Low (M-Th)
Northern Charlotte: Moderate (M-Th)
Northern Charlotte, bay regions: Moderate (M-Th)

Gulf of Mexico Harmful Algal Bloom Bulletin

Region: Texas
Thursday, 13 October 2016
NOAA National Ocean Service
NOAA Satellite and Information Service
NOAA National Weather Service
Last bulletin: Tuesday, October 11, 2016



Satellite chlorophyll image with possible *K. brevis* HAB areas shown by red polygon(s), when applicable. Points represent cell concentration sampling data from October 3 to 13: red (high), orange (medium), yellow (low b), brown (low a), blue (very low b), purple (very low a), pink (present), and green (not present). Cell count data are provided by Texas Parks and Wildlife Department. For a list of sample providers and a key to the cell concentration categories, please see the HAB-OFS bulletin guide:

http://tidesandcurrents.noaa.gov/hab/hab_publication/habfs_bulletin_guide.pdf

Detailed sample information can be obtained through the Texas Parks and Wildlife Department at:
http://www.tpwd.state.tx.us./landwater/water/environconcerns/hab/redtide/status.phtml

Conditions Report

Karenia brevis (commonly known as Texas red tide) ranges from not present to high concentrations along the Texas coast from the Corpus Christi Bay to Rio Grande regions. *K. brevis* concentrations are patchy in nature and levels of respiratory irritation will vary locally based upon nearby bloom concentrations, ocean currents, and wind speed and direction. The highest level of potential respiratory irritation forecast for Thursday, October 13 through Monday, October 17 is listed below:

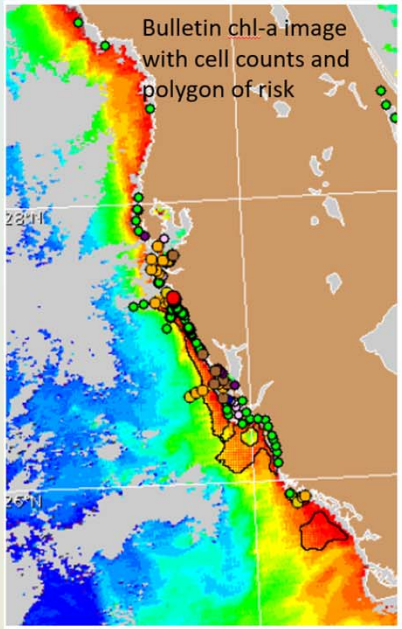
County Region: Forecast (Duration)
Bay region-Corpus Christi Bay: Moderate (Th-M)
Bay region-Upper Laguna Madre: Very Low (Th-M)
Aransas Pass to PINS: Moderate (Th-M)
Padre Island National Seashore region: Moderate (Th-M)
Mansfield Pass to Beach Access 6 region: Moderate (Th-Su), Low (M)
Beach Access 6 to Rio Grande region: Moderate (Th-Su), Low (M)
Bay region-Lower Laguna Madre to Laguna Vista: Low (Th-M)
All Other Texas Regions: None expected (Th-M)

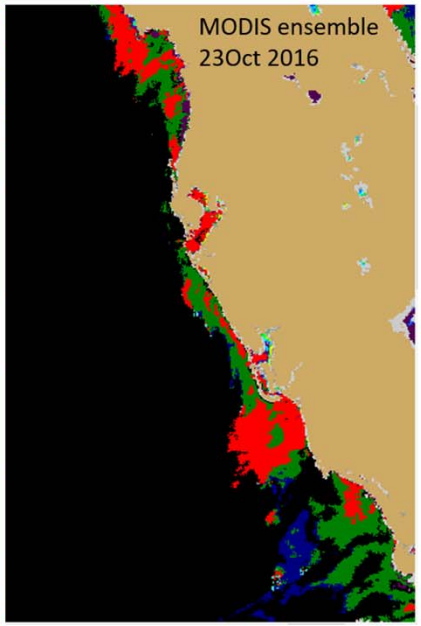
Check http://tidesandcurrents.noaa.gov/hab/beach_conditions.html for recent, local observations. Over the past few days, reports of respiratory irritation and discolored water have been received from the Corpus Christi Bay region.

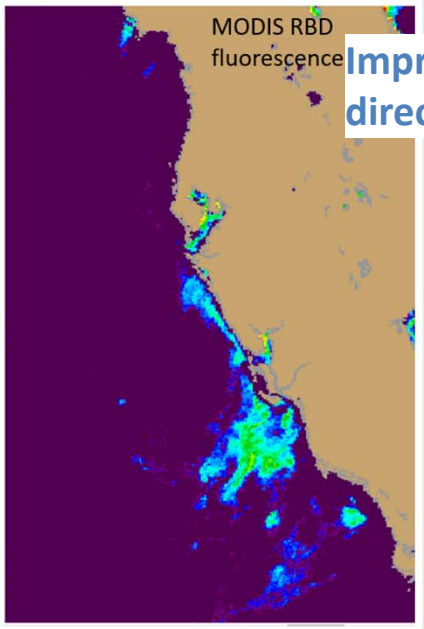
Analysis

Karenia brevis concentrations range between 'not present' and 'high' along the Texas coast from Aransas Pass to the Rio Grande (TPWD; 10/11-13). In the Corpus Christi Bay region, sampling this week continues to indicate up to 'high' *K. brevis* concentrations throughout the bay with corresponding reports of respiratory irritation and discolored water (TPWD; 10/11-12). Sampling from Texas A&M University's Imaging FlowCytobot, located on the Port Aransas ship channel, continues to indicate up to 'very low a' *K. brevis* concentrations (TAMU; 10/11-12). Sampling in the Upper Laguna Madre detected a 'very low a' *K. brevis* concentrations where previous sampling indicated *K. brevis* was not present (TPWD; 10/11). Recent sampling in the Padre Island National Seashore region continues to indicate up to 'low b' *K. brevis* concentrations (TPWD; 10/12). New sampling around the Lower Laguna Madre to Laguna Vista region continues to confirm *K. brevis* concentrations have decreased in the last week with only 'background' concentrations detected on 10/10 (Texas Red Tide Rangers). Detailed sample information and a summary of impacts can be obtained through Texas Parks and Wildlife Department at: http://www.tpwd.state.tx.us./landwater/water/environconcerns/hab/redtide/status.phtml. For information on area shellfish restrictions, contact the Texas Department of State Health Services.

Florida, developing improved respiratory forecast



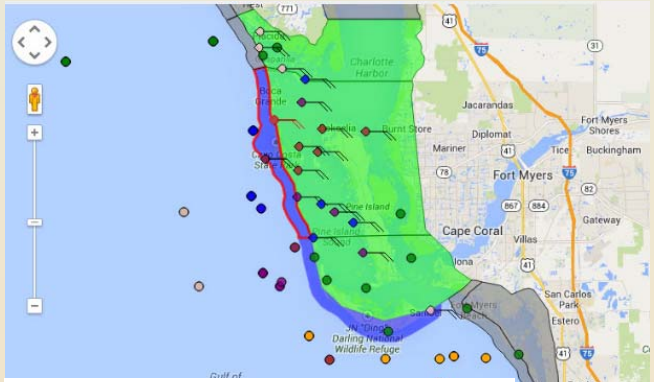




Improved satellite data to direct beach sampling

HABscope developed to bring in volunteer networks

NOAA/NOS, GCOOS, Mote Marine Lab, NASA



Prototype forecast tool combining NDFD wind with cell concentrations.

Video frame of *K. brevis* cells

Example application: Lake Erie Forecasts, run routinely since 2008

Experimental Lake Erie Harmful Algal Bloom Bulletin

National Centers for Coastal Ocean Science and Great Lakes Environmental Research Laboratory

27 July 2015, Bulletin 04

The Microcystis cyanobacteria bloom continues in the western basin. The bloom extends from west of West Sister Island, veering southward to the coast, then curving to the northeast through the islands toward the central basin and up to the Canadian coast

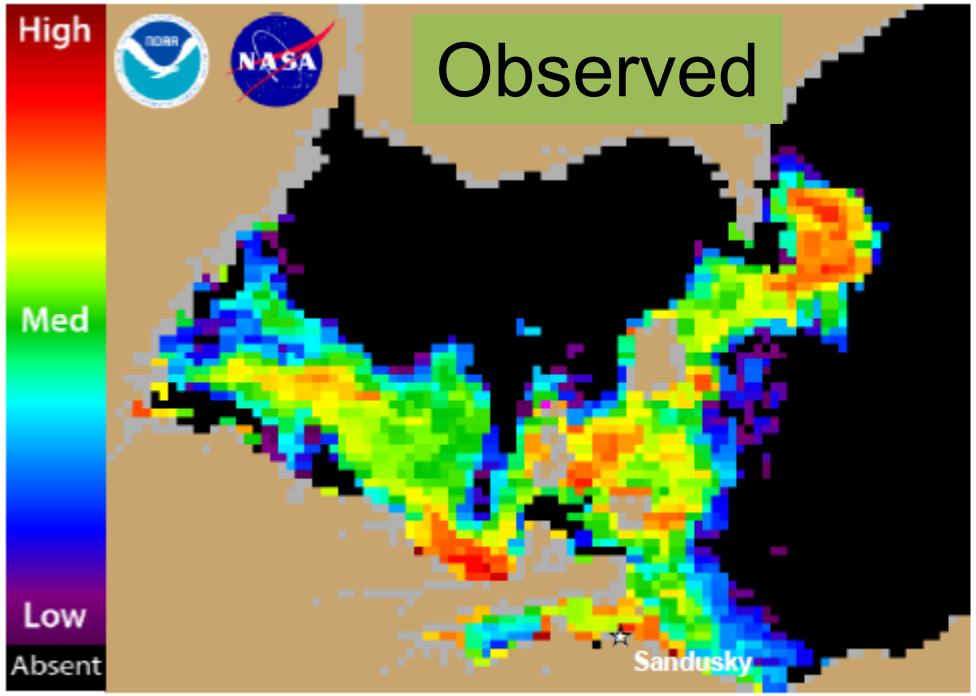


Figure 1. Cyanobacterial Index from NASA's MODIS-Terra data collected 24 July 2015 at 12:00 pm EDT. Grey indicates clouds or missing data. Black

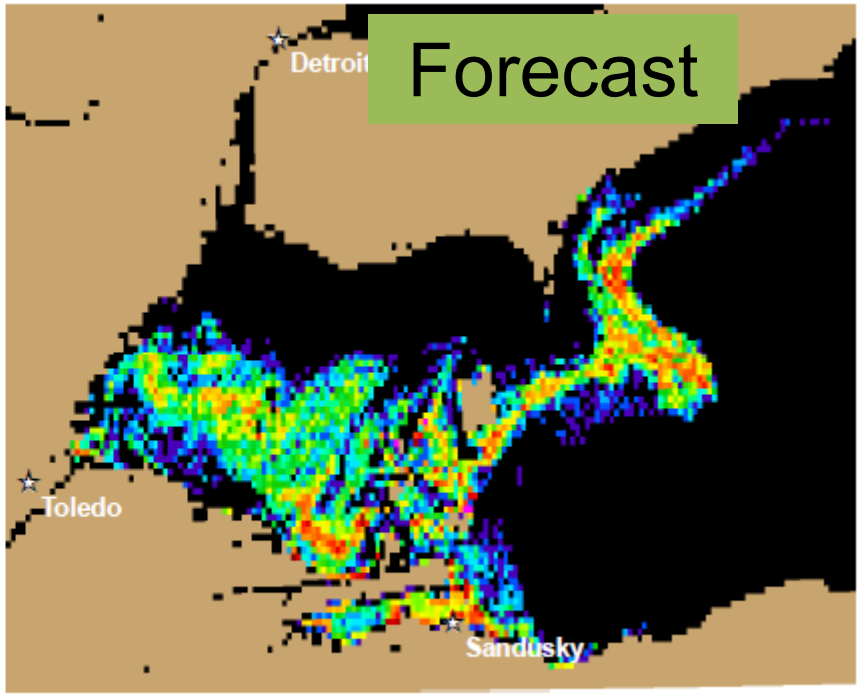
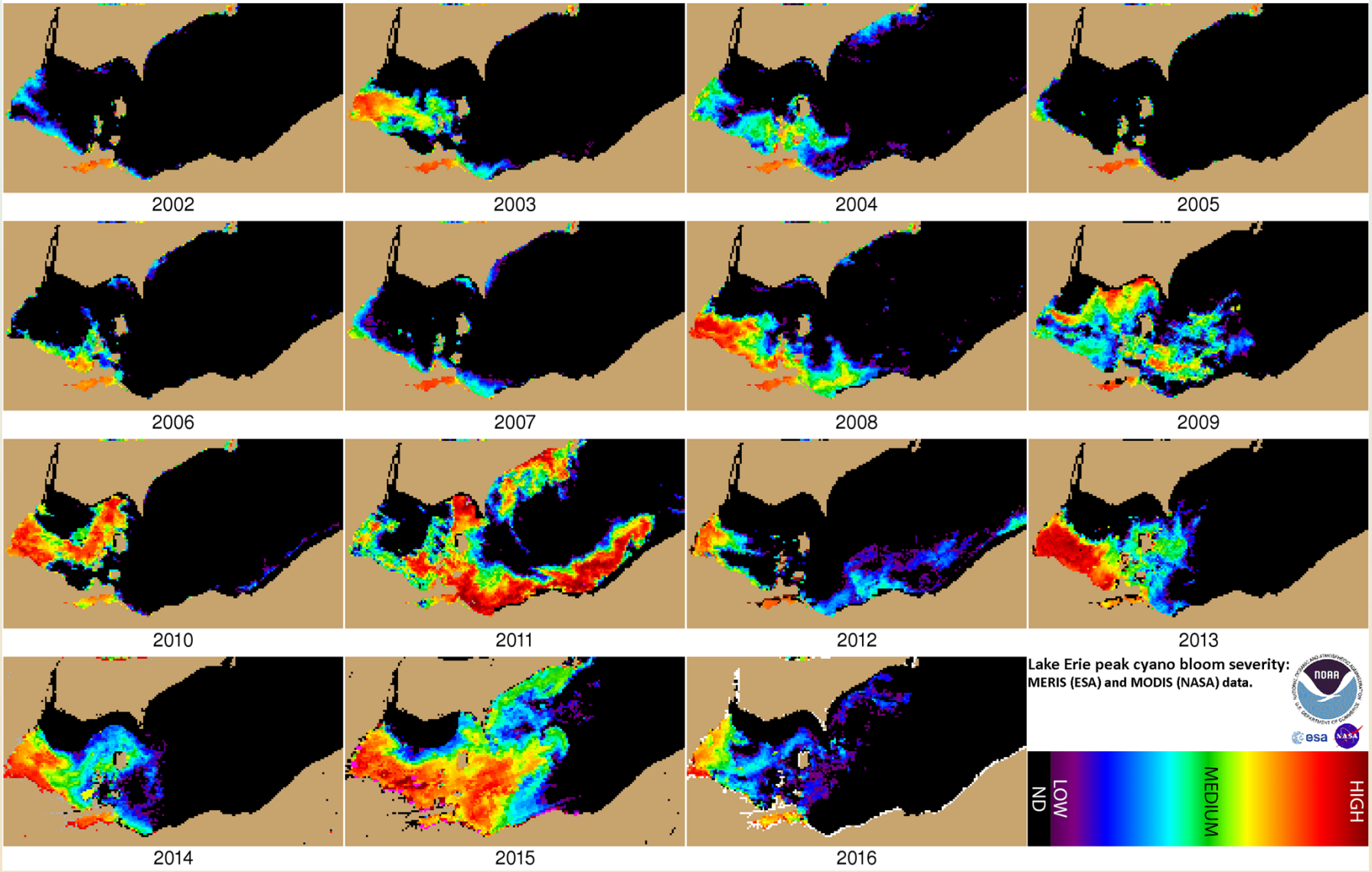


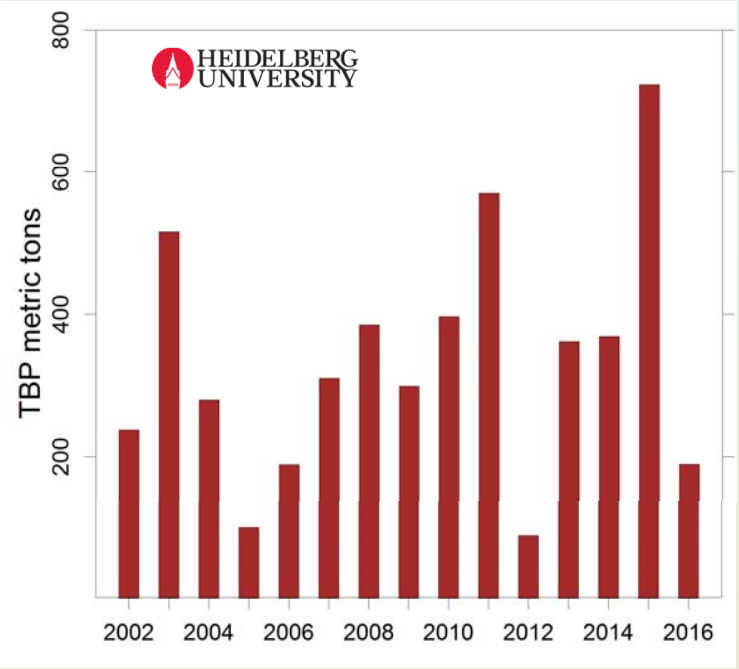
Figure 2. Nowcast position of bloom for 27 July 2015 using GLCFS modeled currents to move the bloom from the 24 July 2015 image.

http://coastalscience.noaa.gov/research/habs/forecasting

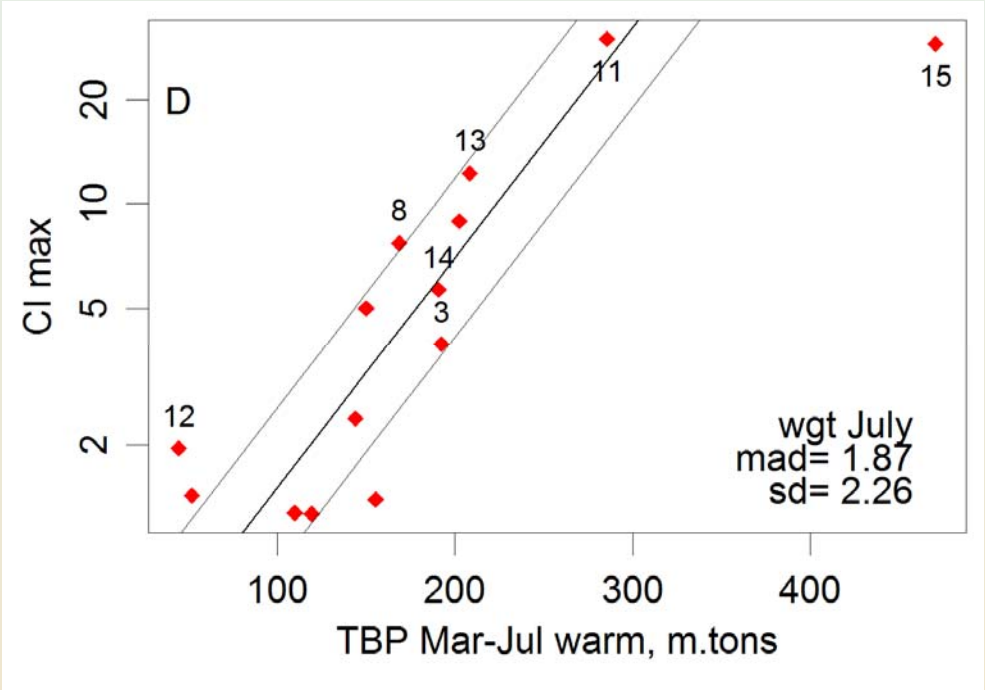
Annual assessment of blooms

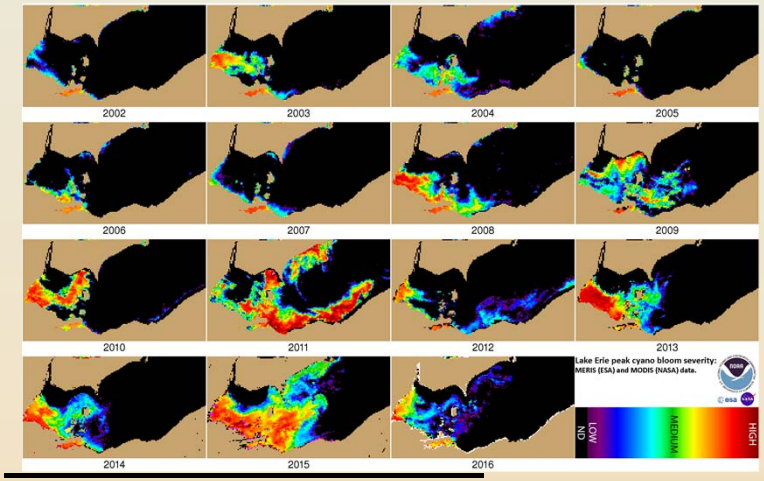


Comparison with Phosphorus Load



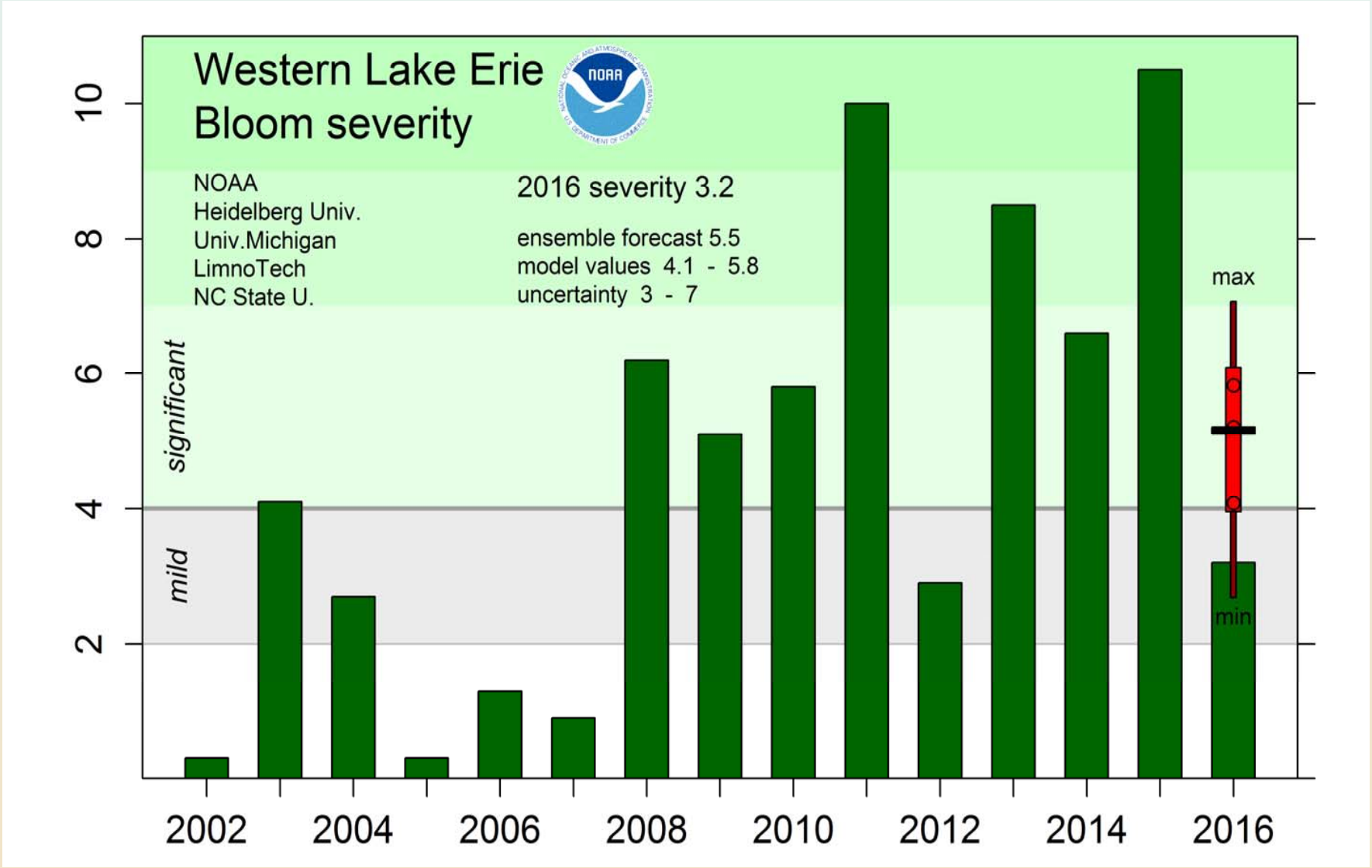
compare bloom biomass with total bioavailable phosphorus (TBP)





2016 Seasonal forecast milder than 2014 & 2015.

Correct, but several models overestimate internal loading from 2015



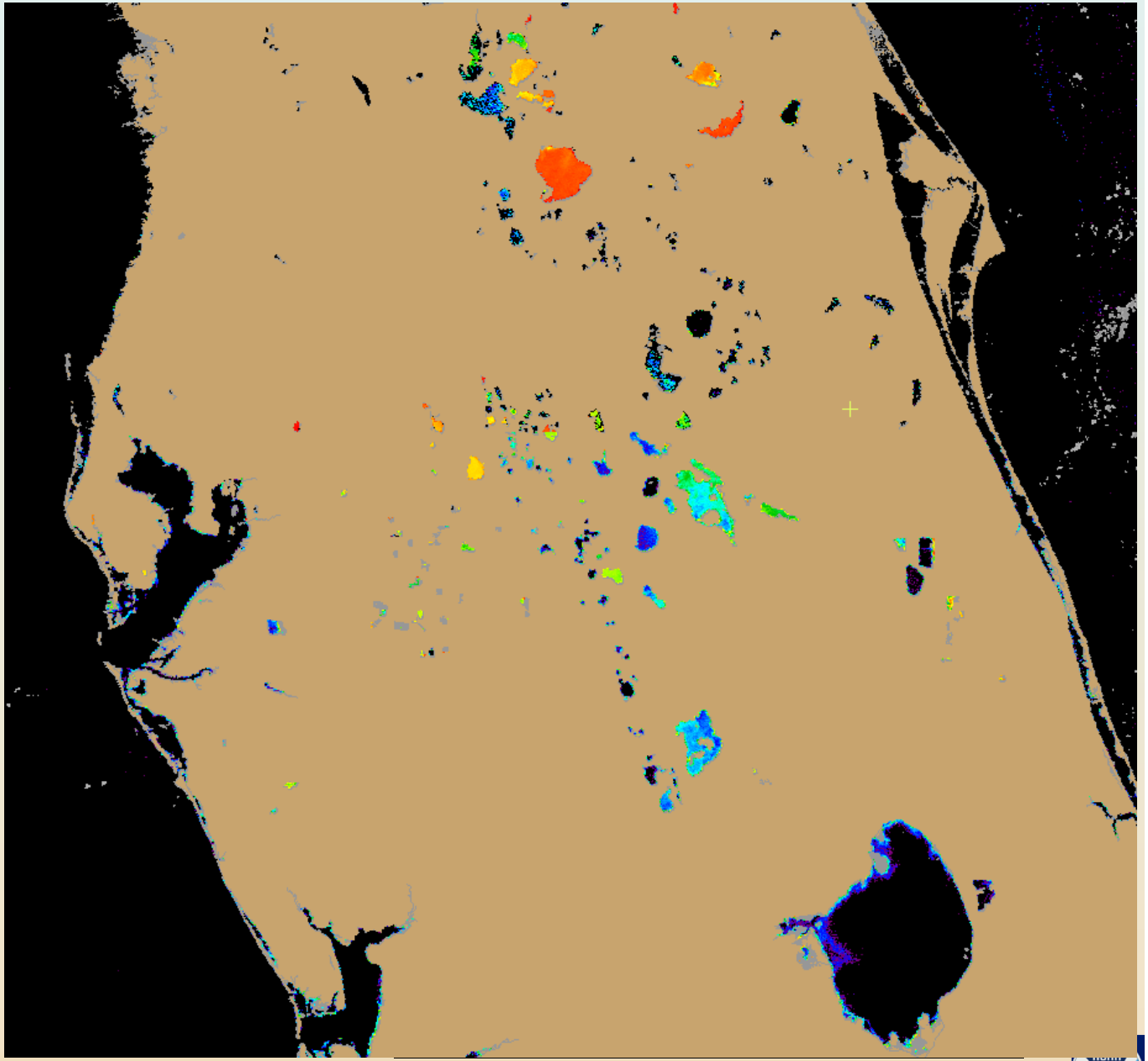
Detecting HABs in Freshwater Cyanobacteria Assessment Network

- Satellite **monitoring in larger lakes and reservoirs, OLCI and MERIS**
- **Estimate human exposure** to cyanotoxins
- **Disseminate info** → expedient public health advisories
- **Decrease costs** of monitoring
- **Reduce exposures**
- **Create a standard** approach for early HAB detection based on new satellite data (OLCI)
- Retrospective with MERIS
- Evaluate Landsat

EPA, NASA, NOAA, and USGS

Sentinel-3 satellite
Launched February 2016

Cyano density 09 May 2018, Sentinel-3a (Copernicus program)

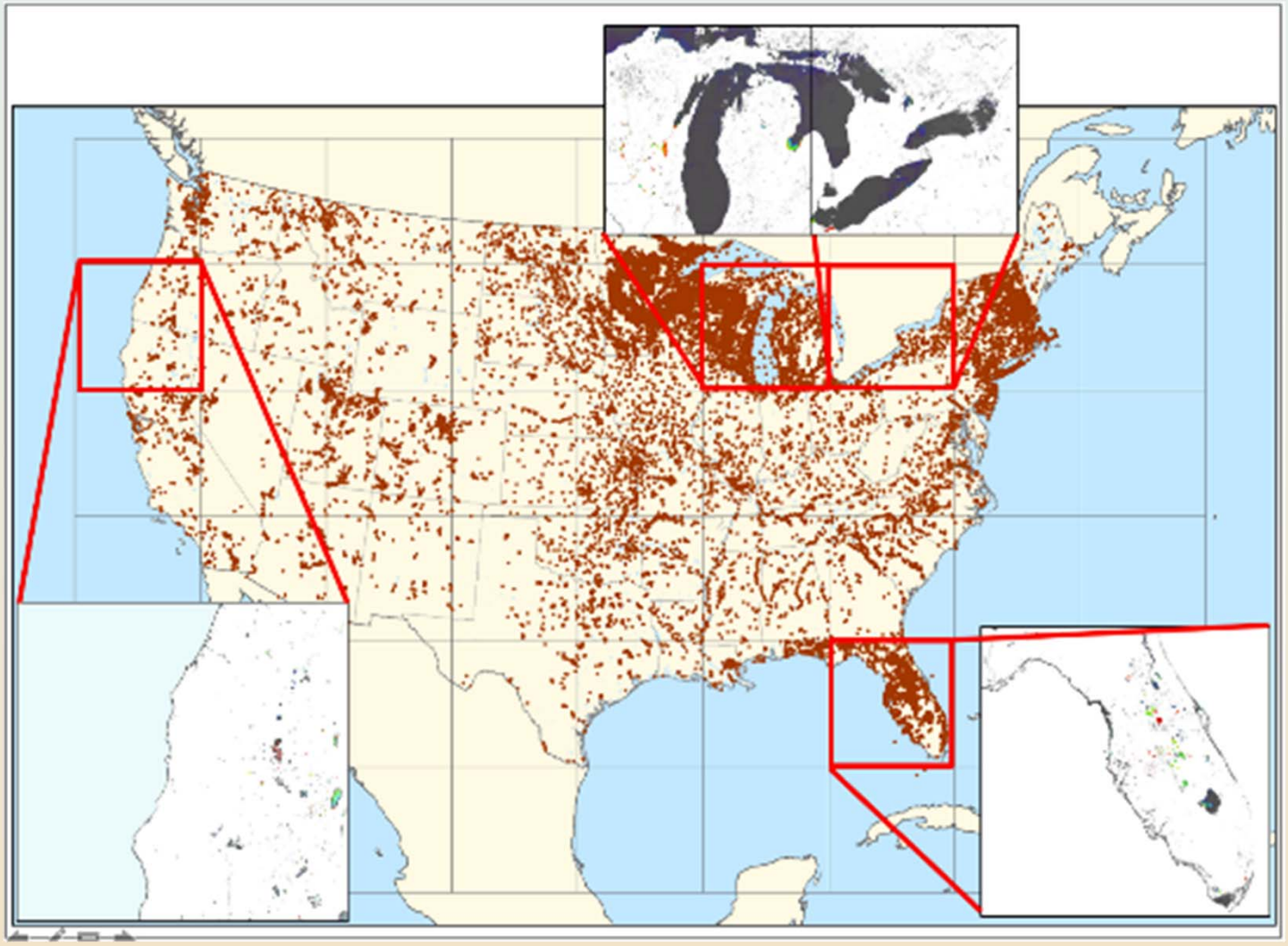


CyAN. National scope

Red points are locations of water quality data.

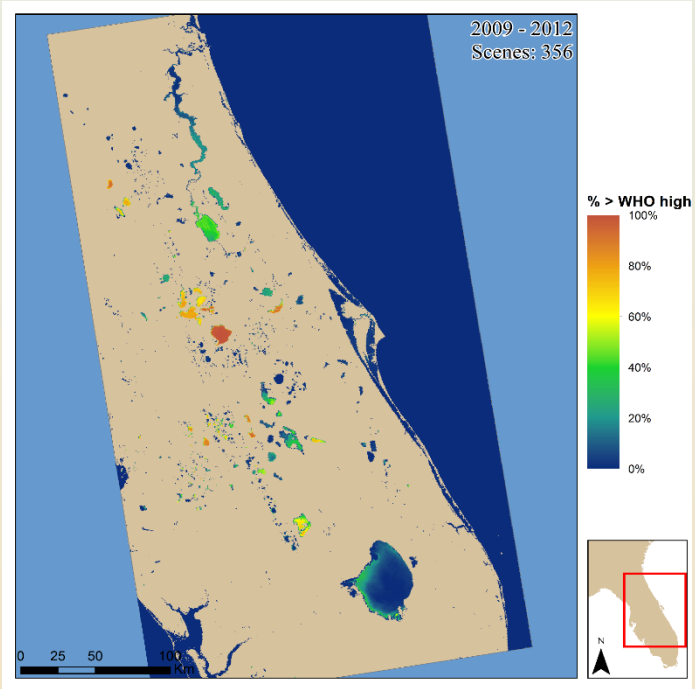
MERIS tiles outlines in gray.

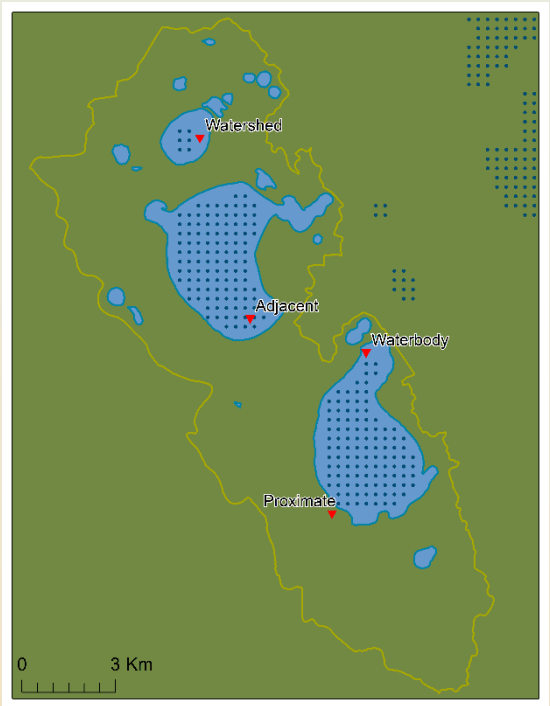
Insets are test MERIS files

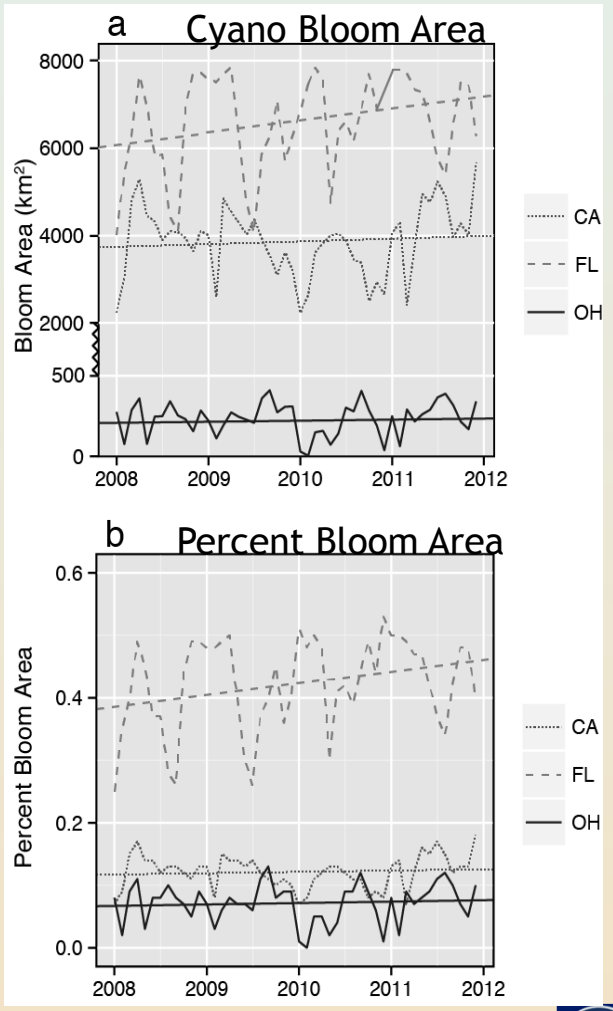


From Lake Erie to rest of country, CyAN, Collaboration with EPA, USGS, NASA

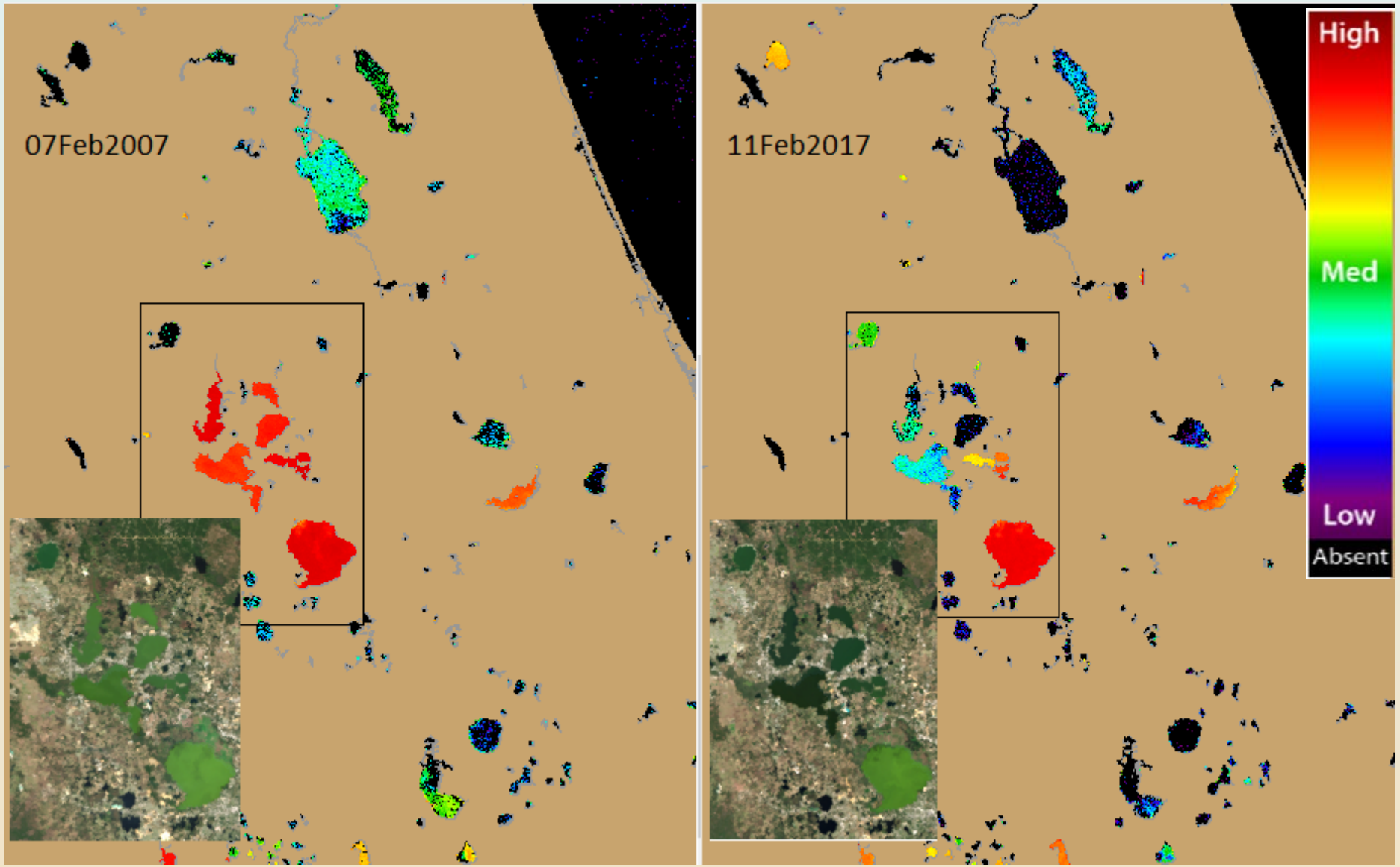
- Testing “bulk” methods with time series analysis of FL, OH, and CA (2008-2011)
- Frequency maps and surface drinking water intake monitoring methods







Northern Florida clear Scenes, MERIS to OLCI comparison



Lake Okeechobee

South Florida Water Mgmt District (SFWMD,"Softmu") and US ACOE

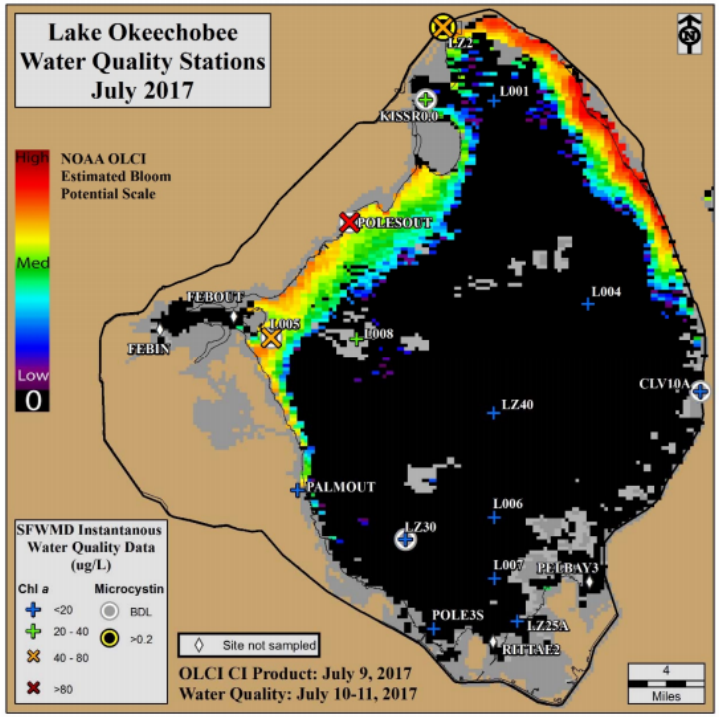
Product evaluatio

SFWMD using daily products to improve monitoring from their limited weekly flyovers (Lake Okeechobee is 30 miles across)

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Lake Okeechobee Water Quality

July 10 - 11, 2017		
Site	Chlorophyll a (ug/L)	Microcystin (ug/L)
Nearshore Stations		
FEBIN	Not Sampled	
FEBOUT	Not Sampled	
KISSR0.0	34.8	0.2
LZ2	44.2	0.3
LZ25A	5.2	
PALMOUT	6.5	
PELBAY3	Not Sampled	
POLE3S	5.5	
POLESOUT	102.0	0.2
RITTAE2	Not Sampled	
Pelagic Stations		
L001	12.1	
L004	5.3	
L005	54.5	0.2
L006	5.9	
L007	2.5	
L008	23.9	
LZ30	15.5	0.2
LZ40	6.1	
CLV10A	13.2	0.2



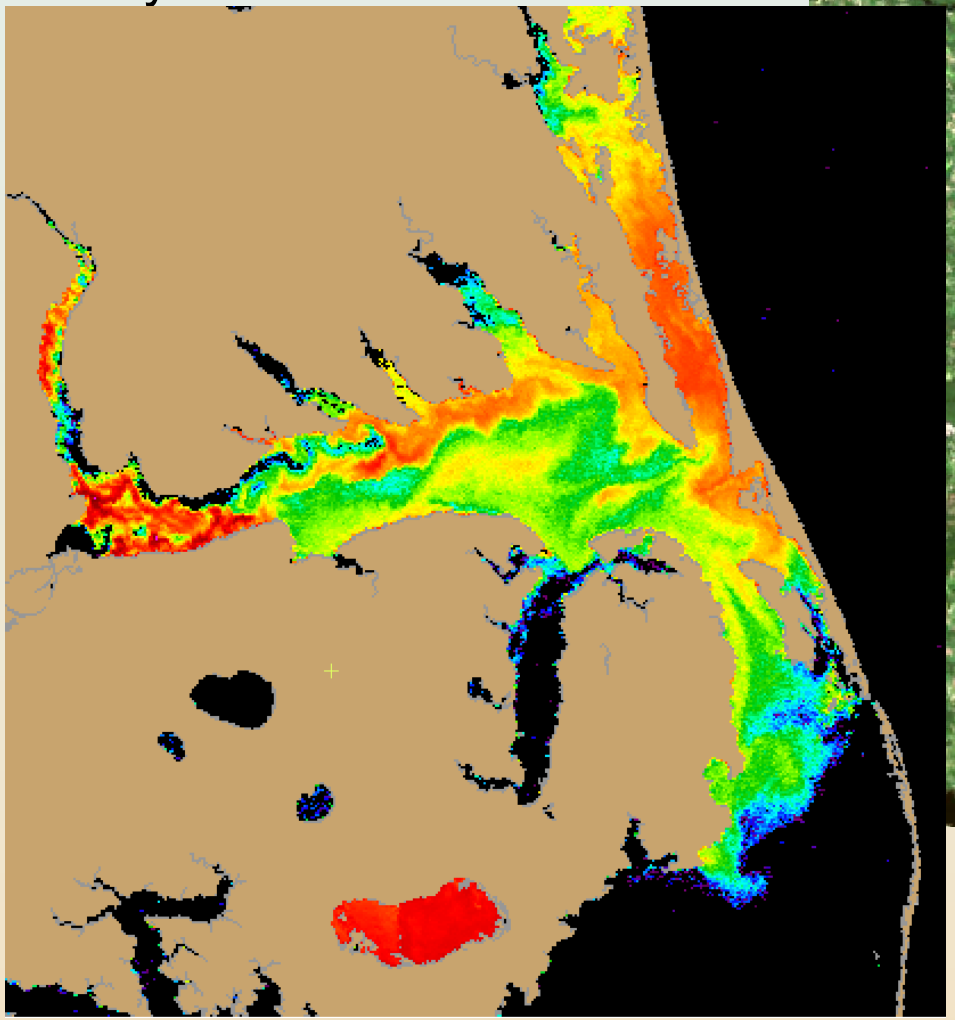
www.sfwmd.gov/news-events/meetings

North Carolina, 01 Aug 2017

Microcystis in Albemarle Sound

Mixed cyanos in Currituck Sound

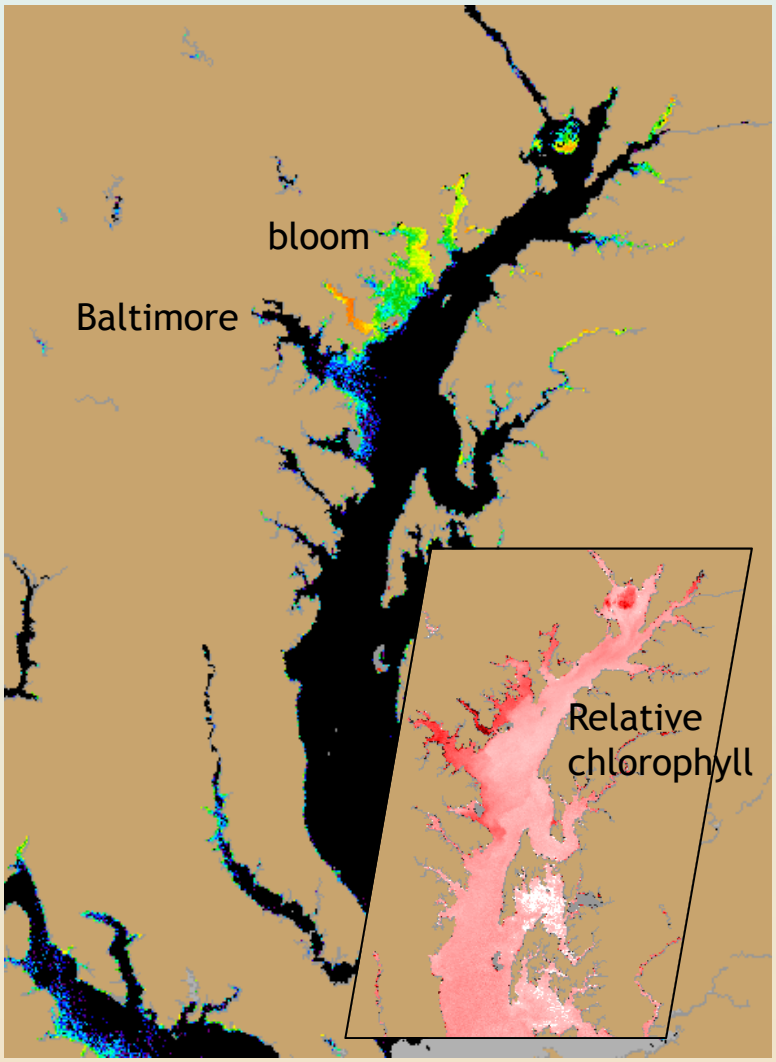
Mixed cyanos in Lake Mattamuskeet



Evaluation of other products

Karlodinium veneficum bloom (not fluorescing) in Chesapeake Bay (12/19/2016)

Maryland Dept of the Environment. Fish kill Dec 19, 2016. *"Karlodinium veneficum*, a toxin producing saltwater algae, pushed remarkably far into the freshwater end of the Chesapeake Bay estuary in 2016."



Sentinel-3 OLCI, Aug 01, 2017

Useful links:

Ecological Forecasting

oceanservice.noaa.gov/ecoforecasting/

NOAA HAB research programs

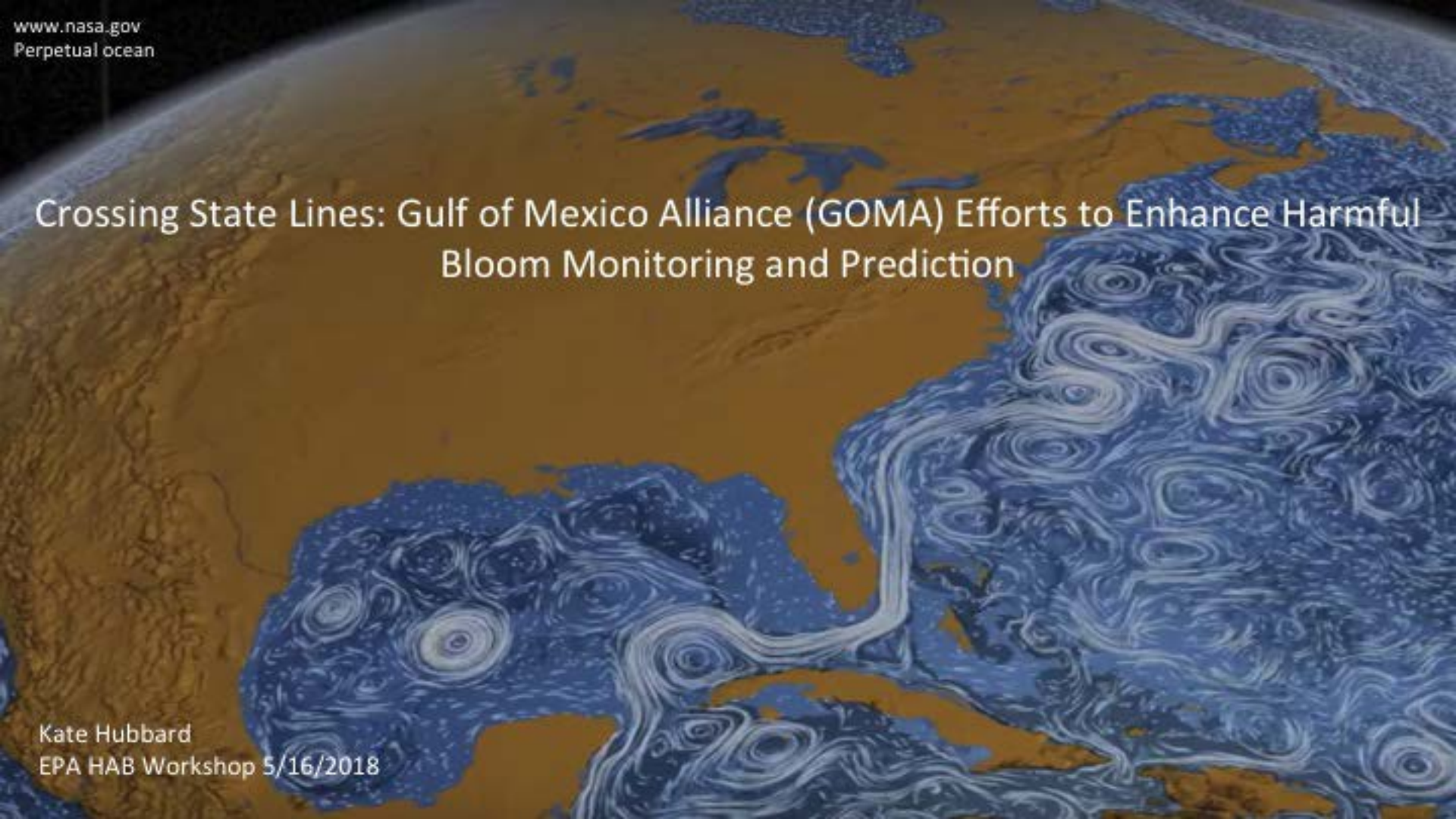
coastalscience.noaa.gov/research/habs/

CyAN

www.epa.gov/water-research/cyanobacteria-assessment-network-cyan-project

Rick Stumpf

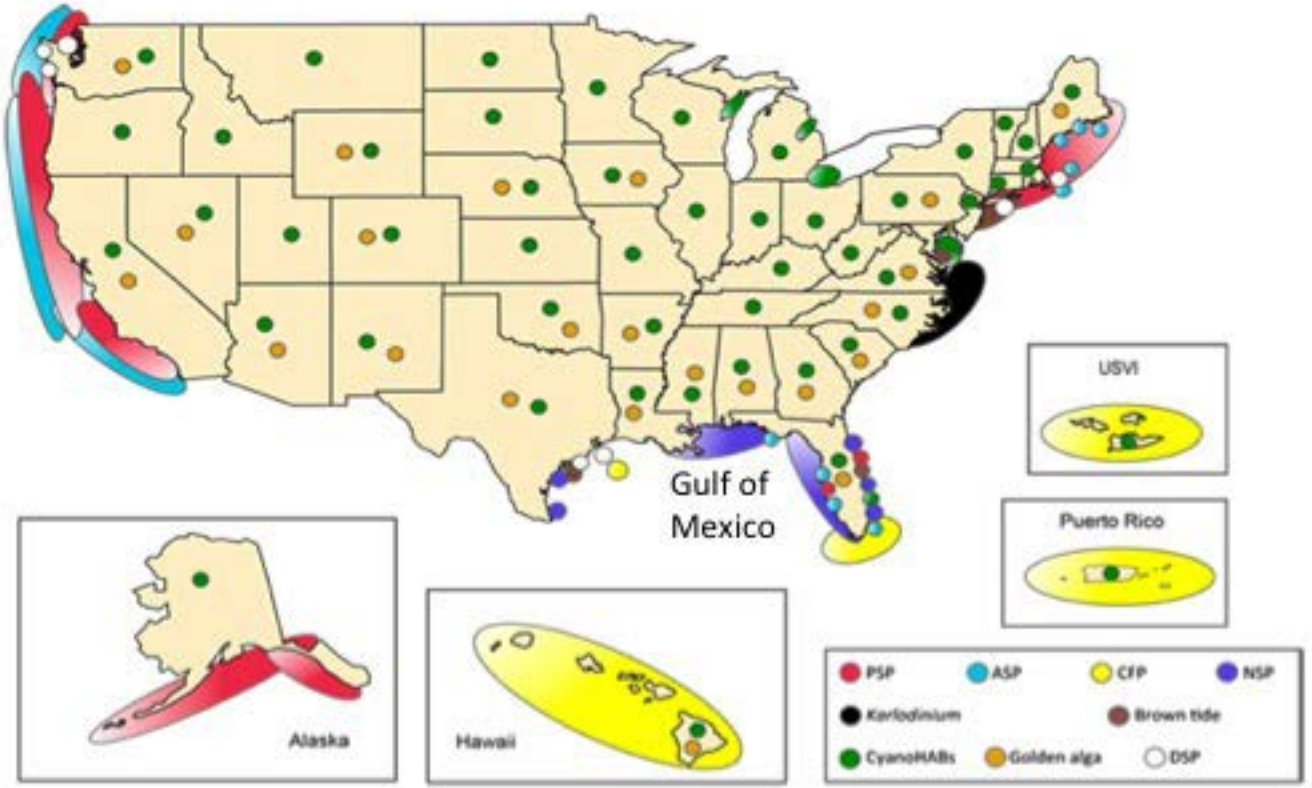
Richard.stumpf@noaa.gov



Crossing State Lines: Gulf of Mexico Alliance (GOMA) Efforts to Enhance Harmful Bloom Monitoring and Prediction

Kate Hubbard
EPA HAB Workshop 5/16/2018

Harmful Algal Bloom (HAB) poisoning syndromes and other impacts – "our" sampling results across the US



https://www.whoi.edu/redtide/regions/us-distribution

Gulf of Mexico Alliance (GOMA) is a partnership of the five U.S. Gulf States, federal agencies, academic organizations, businesses, and other non-profits in the region

http://www.gulfofmexicoalliance.org/

Together, we collaborate regionally to enhance the environmental and economic health of the Gulf of Mexico.

http://www.gulfofmexicoalliance.org/10years/

GULF OF MEXICO ALLIANCE

GULF OF MEXICO ALLIANCE

TEN YEAR SUMMARY REPORT: 2004-2014

A DECADE OF BUILDING PARTNERSHIPS
FOR A HEALTHIER GULF

March 2016

Current GOMA Teams

- Coastal Resilience
- Data and Monitoring
- Education and Engagement
- Habitat Resources
- Water Resources
- Wildlife and Fisheries
- Cross-team initiatives

GOMA's Water Resources Team focuses on:

A. hypoxia/nutrients
B. harmful algal blooms
C. freshwater in-flow, impaired/ non-impaired streams
D. human health (pathogens/mercury)

Water Resources Team

The Team has four primary goals:

- Protect human health, aquatic health, and economic health within the Gulf of Mexico by applying and advancing science and technology, improving education and overall environmental awareness, and enhancing partnerships.
- Identify, prioritize, and pursue additional data and research needed to better characterize, understand, and reduce potential threats to human health or aquatic life
- Identify linkages between water quality, water quantity, water resource sustainability, human health, aquatic health, and economic health
- Support ongoing local, regional, national, and international efforts related to protecting and/or improving water resources within the Gulf of Mexico

Water Resources Team

- Leadership includes representatives from each Gulf state (and for HABs, include persons involved with monitoring and managing HABs and their impacts)
- Recent group activities: panel with industry members at Annual All-Hands Meeting; administered a Request for Proposals through Gulf Star; HAB sensor trainings at GOMA/regionally

GULF STAR

GULF OF MEXICO ALLIANCE

WATER RESOURCES GULF STAR AWARDS

Collaboration and leveraging encouraged!!

2016 Awards

https://gulfofmexicoalliance.org/tools-and-resources/gulf-star-overview/gulf-star-2016-awards/

- Expansion of glider operations to inform harmful algal bloom prediction in the Gulf of Mexico (Gulf-wide)
- Expansion of Harmful Algal Bloom Genetic Sensor Network (Gulf-wide)
- Nutrient Reduction: Social and Civil Engagement (Mississippi)

2017 Awards

https://gulfofmexicoalliance.org/tools-and-resources/gulf-star-overview/2017-gulf-star-awards/

- Citizen science water monitoring in the Florida Panhandle (Florida)
- Louisiana Inshore to Offshore Water Monitoring (Louisiana)

GULF OF MEXICO ALLIANCE

GULF STAR

GULF OF MEXICO ALLIANCE

Modified from slide provided by A. Corcoran

WATER RESOURCES GULF STAR AWARDS

Collaboration and leveraging encouraged!!

2016 Awards

https://gulfofmexicoalliance.org/tools-and-resources/gulf-star-overview/gulf-star-2016-awards/

- Expansion of glider operations to inform harmful algal bloom prediction in the Gulf of Mexico (Gulf-wide)
- Expansion of Harmful Algal Bloom Genetic Sensor Network (Gulf-wide)

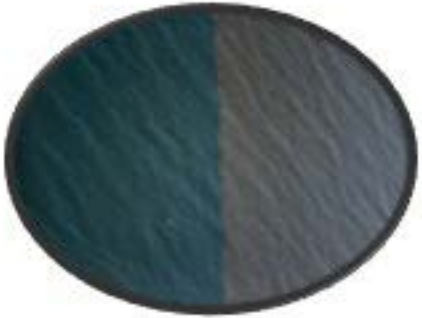
Harmful algal bloom monitoring and research

Florida Department of Agriculture and Consumer Services (FDACS) is the management Authority and monitors SHA Zones

FWC-FWRI provides technical support through statewide harmful algal bloom (HAB) monitoring and biotoxin testing

FWC-FWRI samples across groups and partners with academic and other research partners, regional ocean observing systems, NOAA, FDA, and others to improve HAB and biotoxin monitoring, prediction, and mitigation

Common event response triggers:

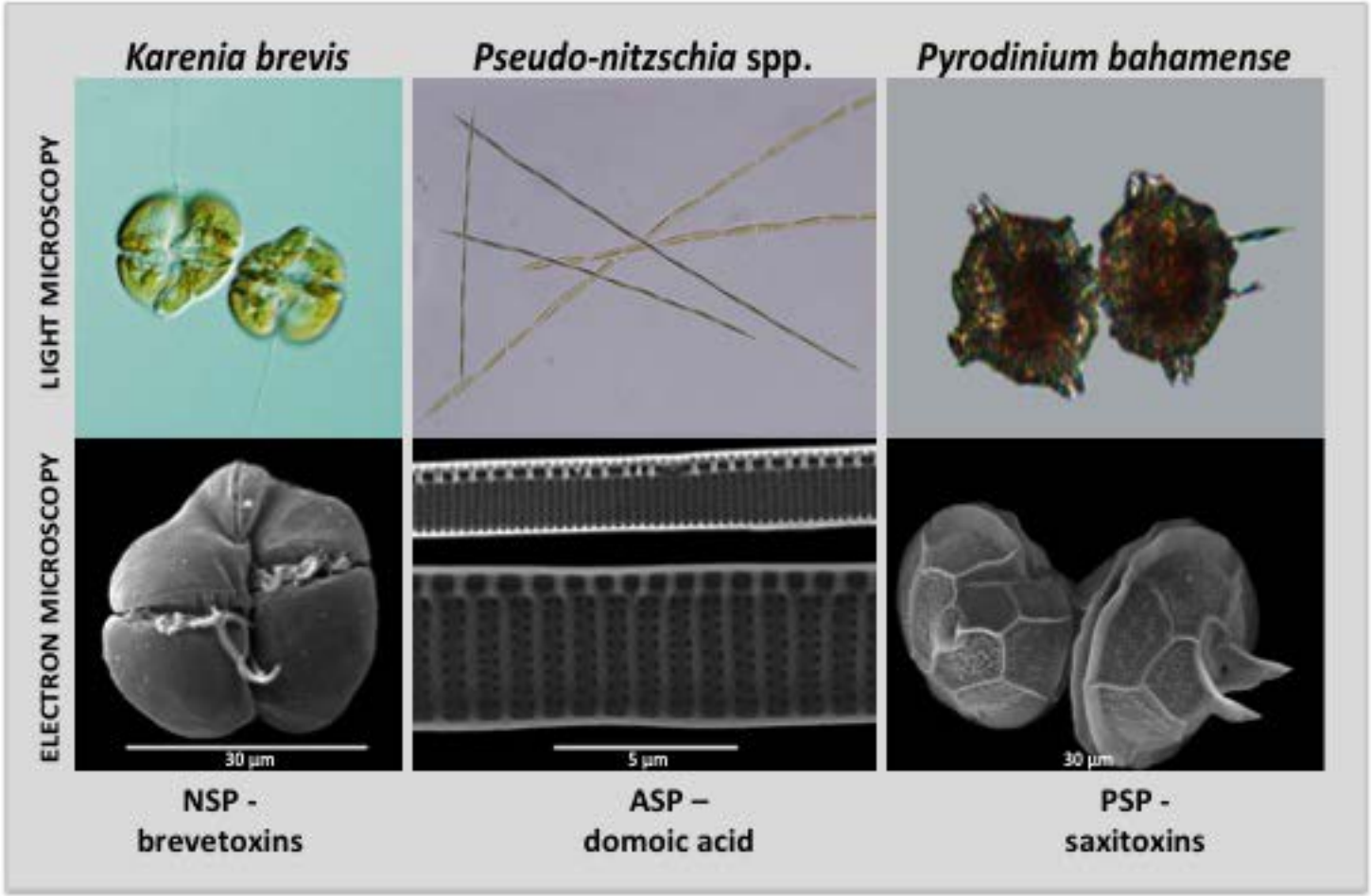


FWRI-HAB/ USCGA

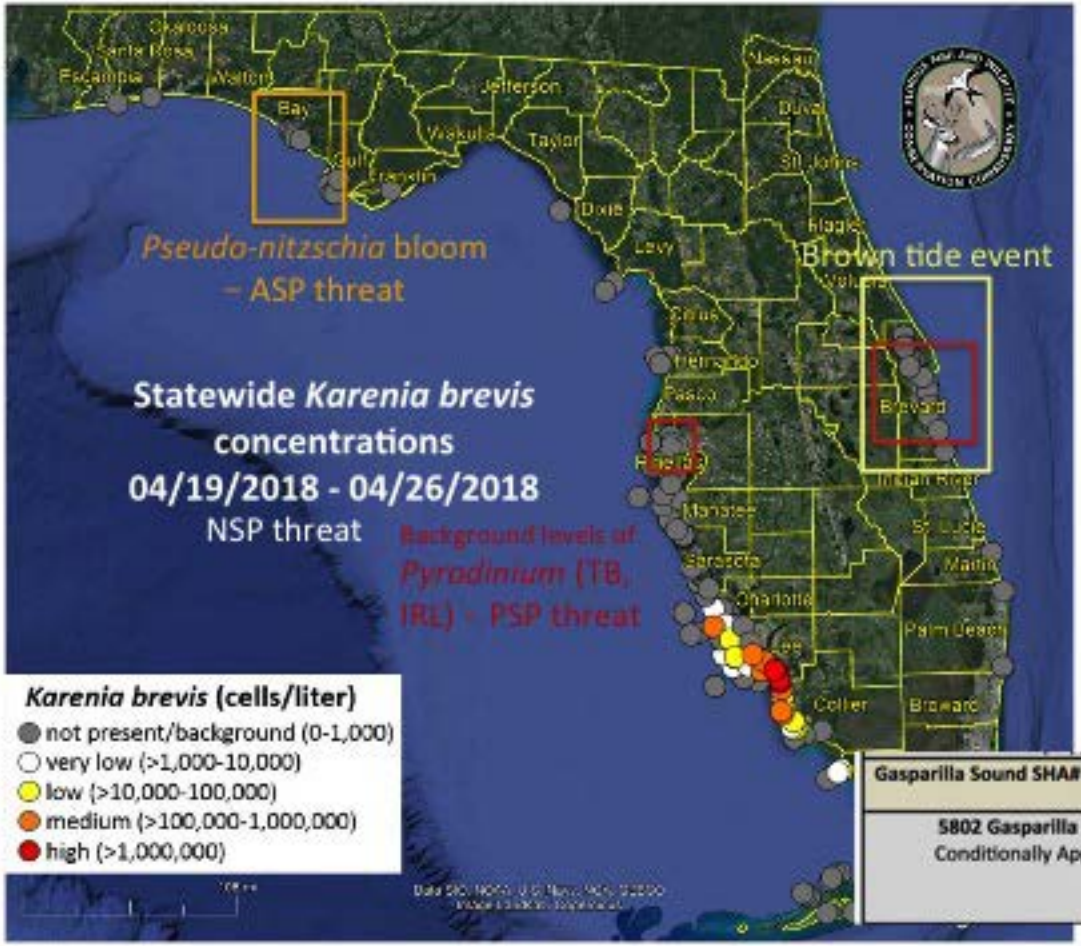
FWRI-Fish and Wildlife Health

FWRI-Manatee Research

Florida's has >50 HAB species (primary offenders below)



Snapshot of what's going on in Florida right now…



FWRI's routine and event response HAB monitoring

microscopy : ~150 samples/week

biotoxin testing: ~70 samples/week

other tests developed/conducted as needed

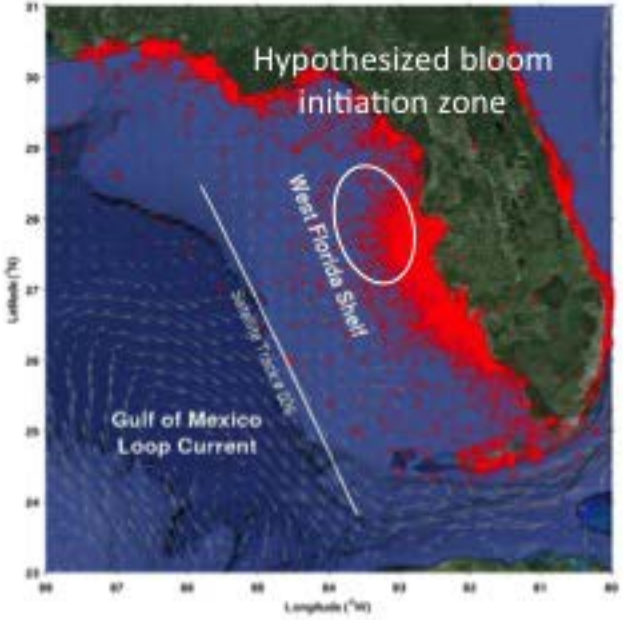
multiple HABs and/or toxins co-occurring in time and/or space

~6 month shellfish harvest area closures related to NSP in some areas (FDACS)

Gasparilla Sound SHA# 58	Status	Date	Reason/Notes
5802 Gasparilla Sound Conditionally Approved	Aquaculture Leases CLOSED	11/14/2017	*Karenia brevis* (Red Tide)
	Public Reefs CLOSED	11/14/2017	*Karenia brevis* (Red Tide)

Tracking and forecasting *Karenia brevis* bloom dynamics

1953-2015 *K. brevis* observations



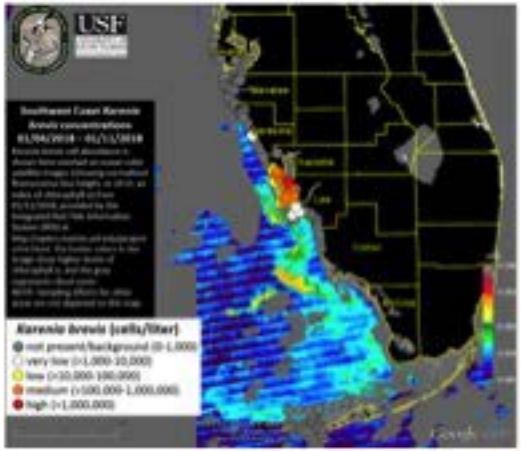
Liu et al. 2016

- Blooms most commonly occur in SW FL but can also occur in the FL Panhandle
- Occasionally, FL *Karenia brevis* blooms are transported east or west into other states
- Hypothesized bloom initiation region has been identified, base largely on prevailing currents/Eckman transport that brings cells onshore at depth

Offshore/subsurface mapping (e.g., via gliders, sampling regimes) for validating models and informing adaptive sampling

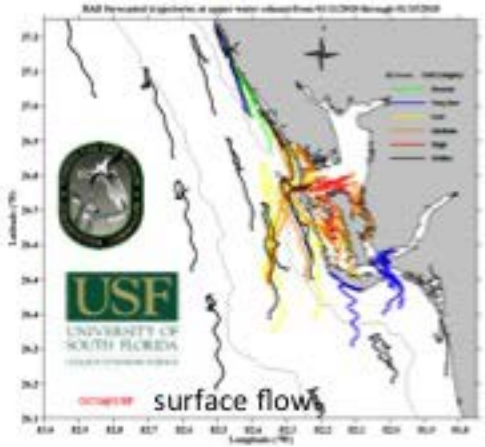
Tracking and forecasting *Karenia brevis* blooms and their impacts in FL

Sea surface chlorophyll for bloom tracking (nFLH product)



http://optics.marine.usf.edu/

FVCOM Circulation Model – 3.5 day bloom trajectories shown

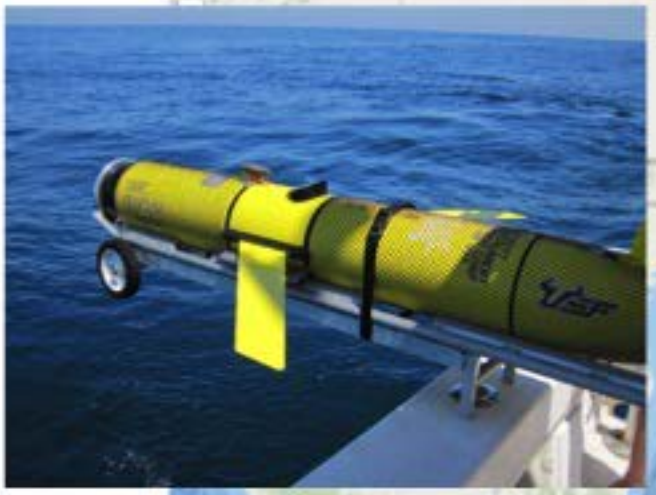


http://cprweb.marine.usf.edu/

NOAA Respiratory Irritation Forecast

https://tidesandcurrents.noaa.gov/hab/gomx.html

Improved observations of bloom dynamics to inform prediction: gliders



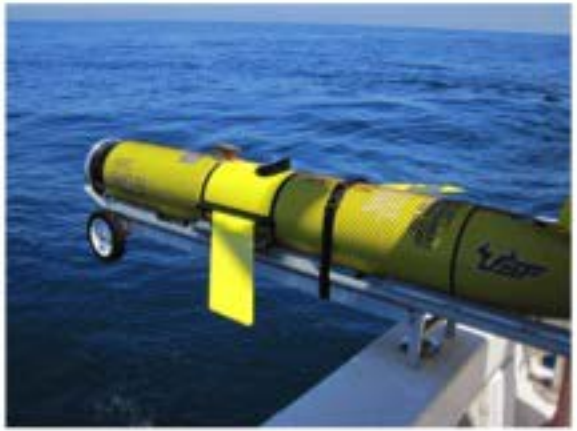
http://gcoos2.tamu.edu/gandalf

Gulf Star Supported HAB Observation Advancement

Goal: The glider project will leverage existing NOAA PCMHAB efforts to integrate observation and modeling to improve bloom prediction for *Karenia brevis* over event to seasonal time scales.

Approach for Gulf Star project

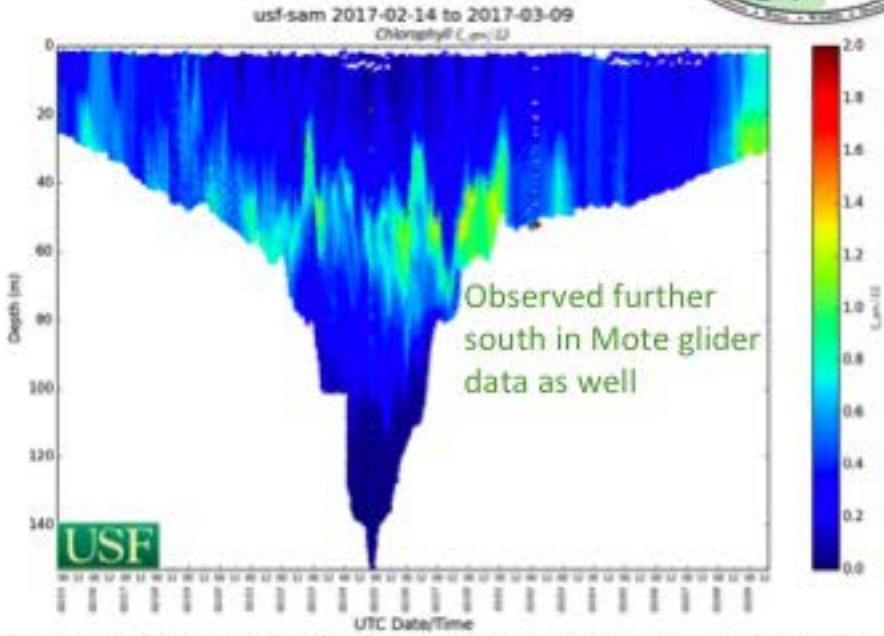
- Extending/enhancing already planned missions in the bloom formative region
- Lead 1-4 project specific efforts with support from other projects (e.g. Panhandle to Tampa)
- USF has several Slocum gliders; has sensors for Temperature, Salinity, Density, Pressure, Chlorophyll FL, CDOM FL, Backscatter at 860nm, and Dissolved Oxygen
- Data is available at http://gcoos2.tamu.edu/gandalf/ (or ask!)



GOMA/FWC/USF Glider Work – 2017 to present

Deployment offshore of Tampa Bay, 2/15/17 to 3/9/17

Fluorescence ~ Chl *a*



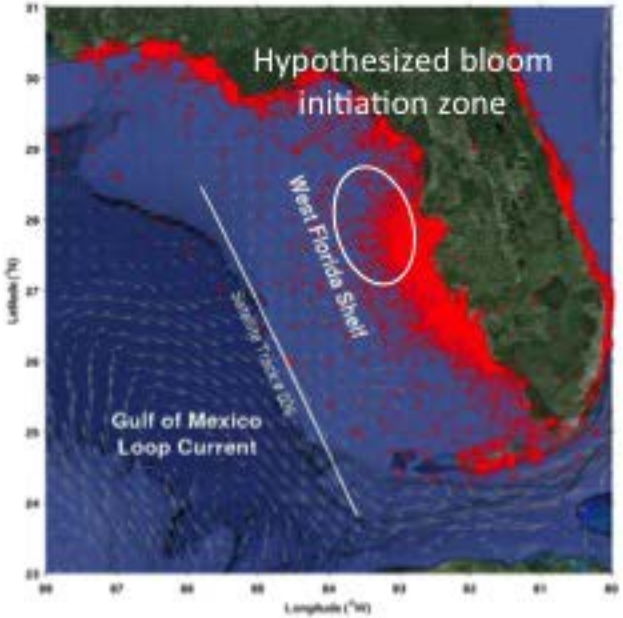
- **Original plans:** 10-14 day mission traversing 60km between the 30 and 55m isobaths (FL RESTORE Act Centers of Excellence Program: USF, FWC-FWRI, NOAA, and Loggerhead Instruments)
- **GOMA augmentation:** mission extended to 24 days to include an across shelf transect (>140 m); FWRI HAB has assisted with deployments/recoveries
- **Where are we now?** Two augmented missions completed; planning underway for additional deployments this summer ideally with vessel support

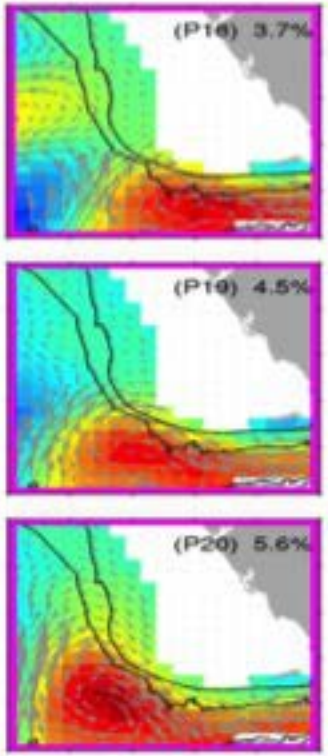
Tracking and forecasting *Karenia brevis* bloom dynamics

1997-2015 Most common patterns in the loop current (based on Sea Surface Height)

Liu et al. 2016

1953-2015 *K. brevis* observations





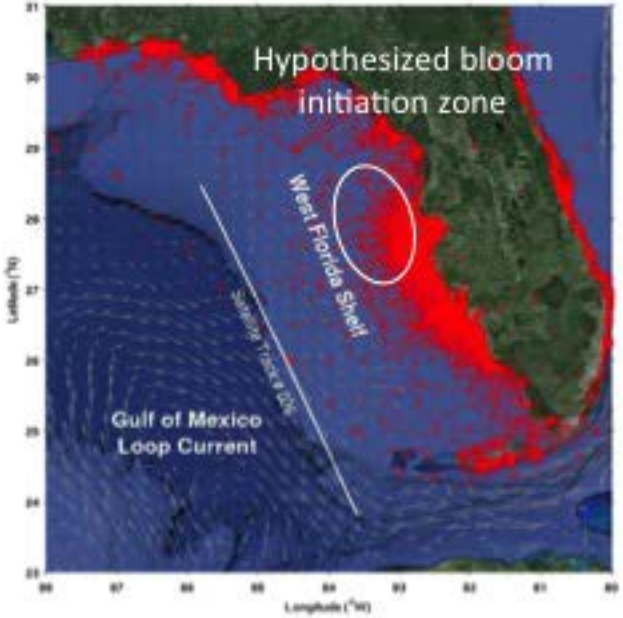
Seasonal hindcasting: majority (*but not all!*) of severe blooms occur during moderate upwelling –> new/persisting observations will help add additional complexity to models and allow for hypothesis testing

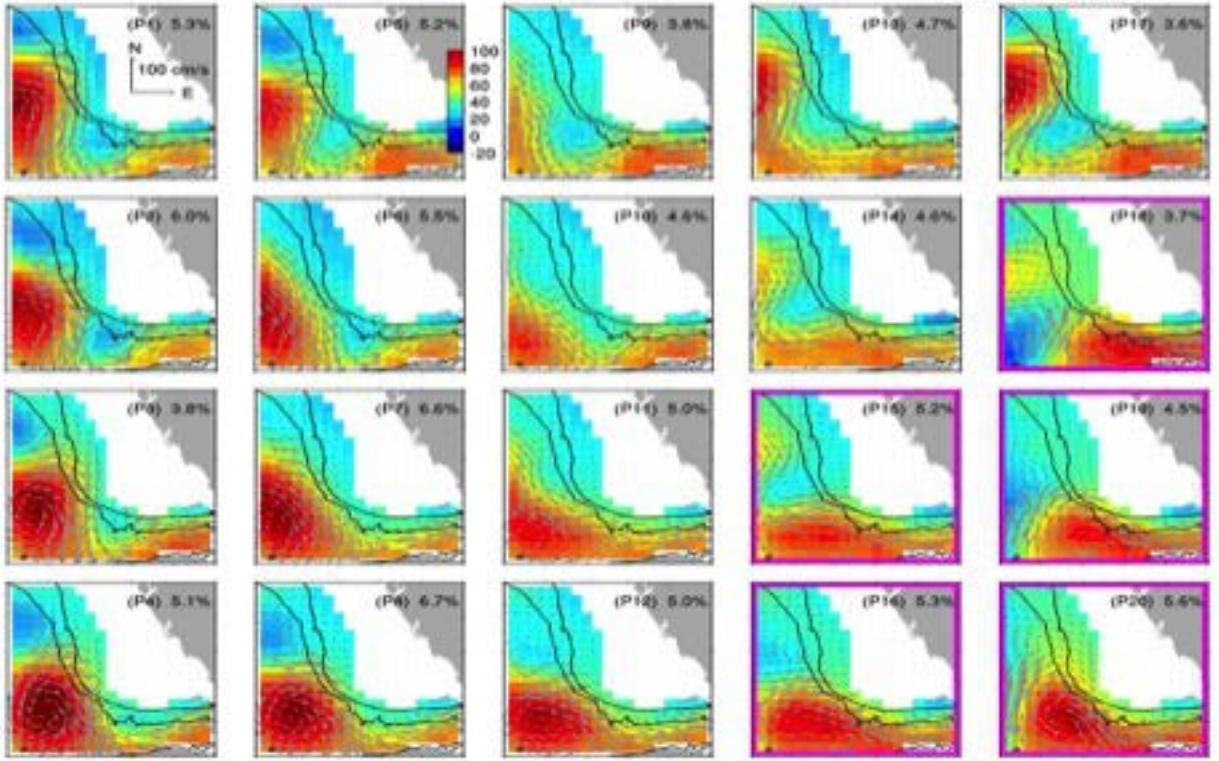
Tracking and forecasting *Karenia brevis* bloom dynamics

1997-2015 Most common patterns in the loop current (based on Sea Surface Height)

Liu et al. 2016

1953-2015 *K. brevis* observations





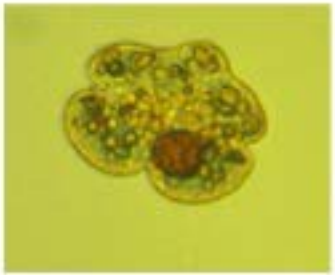
Seasonal hindcasting: majority (*but not all!*) of severe blooms occur during moderate upwelling –> new/persisting observations will help add additional complexity to models and allow for hypothesis testing

Gulf Star Supported HAB Observation Advancement

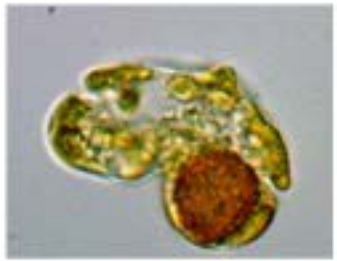
Goal: The probe project will leverage existing NOAA PCMHAB efforts to improve observation of HABs via a simplified in situ genetic detection approach

Approach for Gulf Star project: Design new probes and/or partnerships to inform current and future genetic detection of HABs during routine monitoring and/or event response

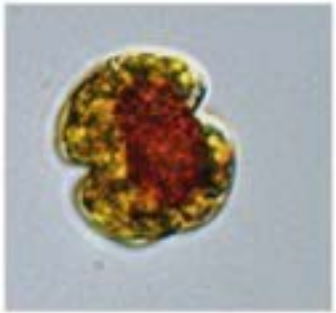
- Light microscopy is used to discern and quantify HAB species in Florida waters. Although *Karenia brevis* is the most common *Karenia* spp., a diversity of morphologically similar HAB species complexes occur in the Gulf of Mexico



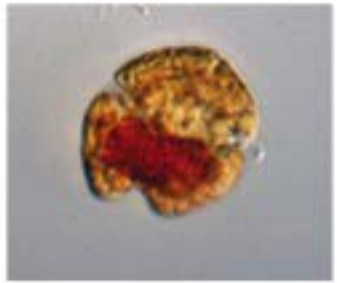
Karenia brevis



Karenia papilionacea



Karenia mikimotoi



Karenia selliformis

hand-held isothermal PCR or NASBA

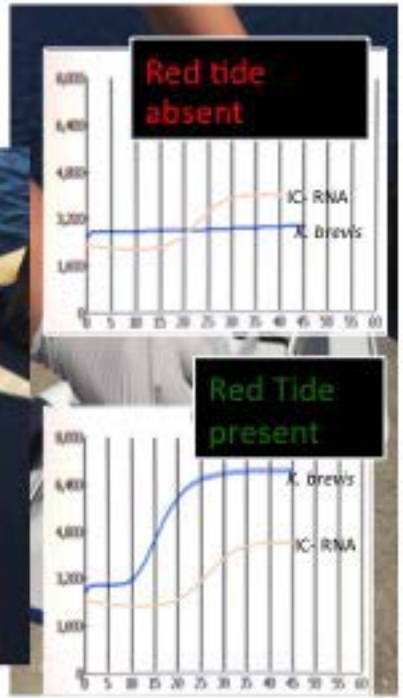
Filter
sample thru
Qiagen
Rneasy
column

Bind total RNA to
RNeasy membrane

Wash

Elute in small volume

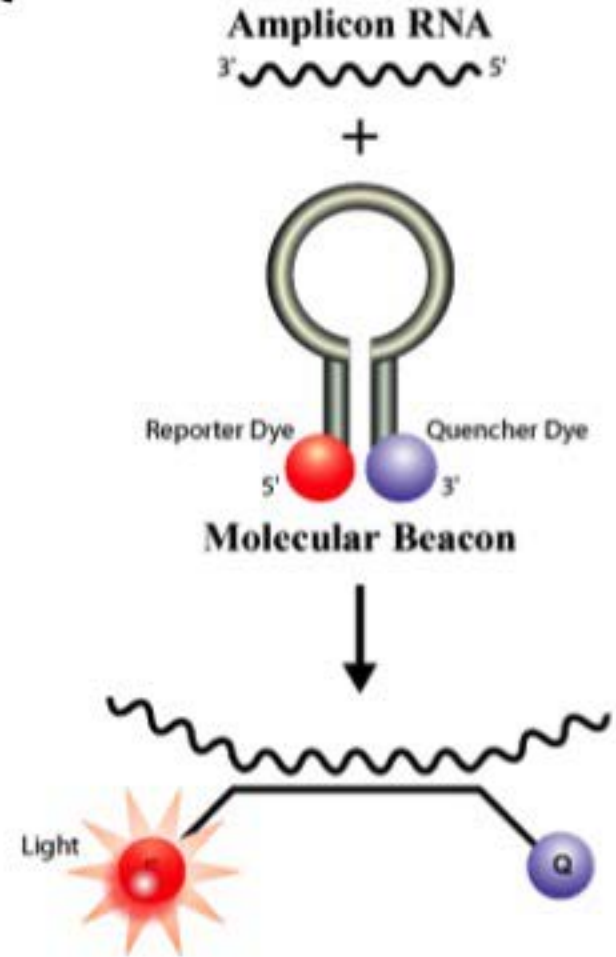
Ready-to-use RNA



NASBA Simplified

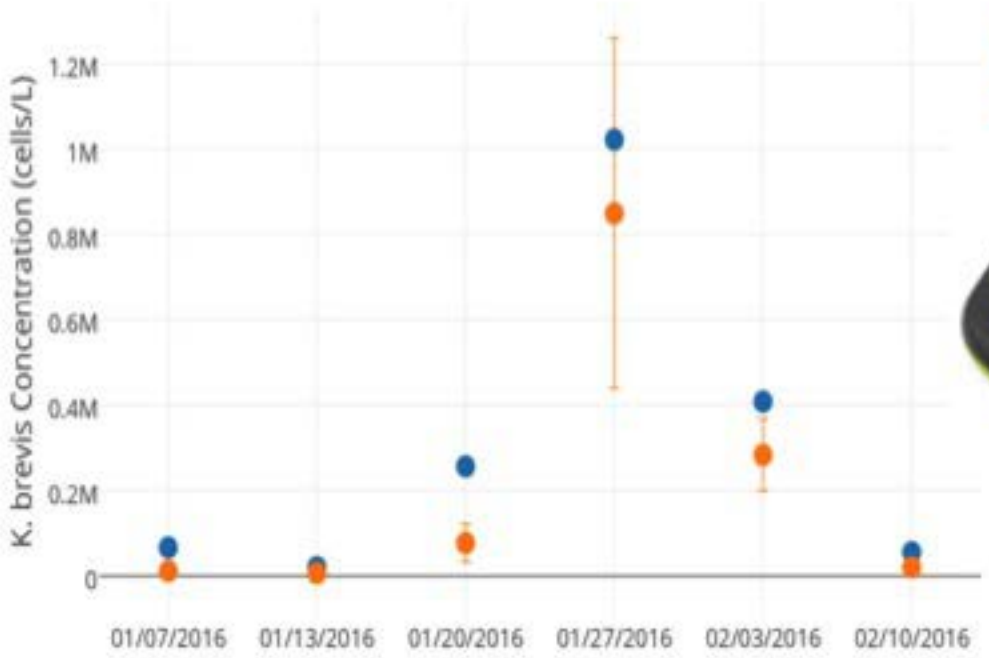
NASBA is a nucleic acid amplification protocol which targets gene-Specific RNA using 3 enzymes at 41°C (isothermal amplification).
Pathogen specific RNA is detected by Molecular Beacons, fluorescent oligonucleotides that bind only to target RNA sequences

Different HABs can be targeted (*Pseudo-nitzschia*)



Preliminary data from PCMHAB Project

Counts from Bayboro Harbor, Tampa Bay, FL are shown



Assay for grouper has also been designed (Paul lab, USF)

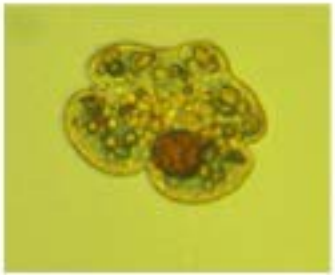
Gulf Star Supported HAB Observation Advancement

Goal: The probe project will leverage existing NOAA PCMHAB efforts to improve observation of HABs via a simplified in situ genetic detection approach

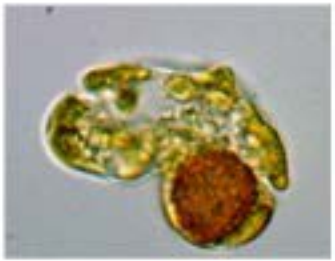
Approach for Gulf Star project: Design new probes and/or partnerships to inform current and future genetic detection of HABs during routine monitoring and/or event response

To date:

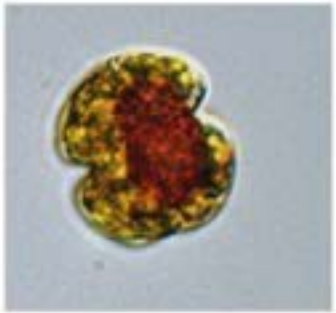
- Training sessions have been held statewide (including a NW training attended by other Gulf states
- DNA sequencing protocols from a single cell/Lugol's preserved field material have been validated
- Population level diversity within *K. brevis* and *K. mikimotoi* has been identified
- Toxic *Pseudo-nitzschia* species targets have been identified.
- Once sequences for GOM species are obtained, probes will be designed/refined/validated



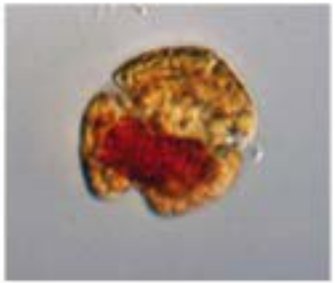
Karenia brevis



Karenia papilionacea



Karenia mikimotoi



Karenia selliformis

WATER RESOURCES GULF STAR AWARDS

Collaboration and leveraging encouraged!!

2016 Awards

https://gulfofmexicoalliance.org/tools-and-resources/gulf-star-overview/gulf-star-2016-awards/

- Expansion of glider operations to inform harmful algal bloom prediction in the Gulf of Mexico (Gulf-wide)
- Expansion of Harmful Algal Bloom Genetic Sensor Network (Gulf-wide)
- Nutrient Reduction: Social and Civil Engagement (Mississippi)

2017 Awards

https://gulfofmexicoalliance.org/tools-and-resources/gulf-star-overview/2017-gulf-star-awards/

- Citizen science water monitoring in the Florida Panhandle (Florida)
- Louisiana Inshore to Offshore Water Monitoring (Louisiana)

GULF OF MEXICO ALLIANCE

GULF STAR

GULF OF MEXICO ALLIANCE


MOTE MARINE LABORATORY
MARINE LABORATORY
Strategies for Mitigating Adverse Effects of HABS
Rich Pierce, Ph.D. Senior Scientist,
Ecotoxicology;
Michael Henry, Staff Scientist
Patricia Blum, Senior Biologist
Samatha Harlow, Chemistry Technician
Ecotoxicology 2017-2018 College Student Interns:
Madison Royer; Sydney Whitlock;
Andrew Wang; Alexandrea Urquiza; Leanne Frank;
Marguerite Kinsella; Burnley Truax

Mote Marine Laboratory
Red Tide Research Program PIs

Kellie Dixon, Ph.D. Senior Scientist

Chemical & Physical Ecology

Tracy Fanara, Ph.D. Staff Scientist

Environmental Health

Vince Lovko, Ph.D. Staff Scientist

Phytoplankton Ecology

Erich Bartels, M.S. Staff Scientist

Coral Reef Monitoring & Assessment

Mote's International Center for
Coral Reef Research & Restoration
Summerland Key, FL

Public Comments and Perceptions About HABS

Legislators: "You have been studying red tide for 20 years, when are you going to get rid of it?"

Citizens solutions : Tow a large iceberg into the Gulf to cool the water & inhibit red tide growth

Tow an electrified grid behind boats to kill the red tide!

Use crop dusting planes to spray herbicides over the Gulf to kill red tide!

Take Home Message:
Do Something About HABs!

Can we? Should we?

Mitigation = reduce/avoid adverse impacts: Toxins, Dead marine life, toxic seafood, airborne toxins, hypoxia

Control = stop cell growth & toxin production, reduce nutrient availability, reduce/destroy cells & toxins

Ecologically sound

Economically Feasible

Logistically Attainable

HAB Mitigation Topics

1. Monitoring, Modeling & Forecasting: Understand the specific HAB species:
   what, where, why, & adverse effects

2. Identify and implement protocol to protect the public from HAB effects; (may be avoidance)

3. Disseminate information to agencies & the general public for avoidance & protection.

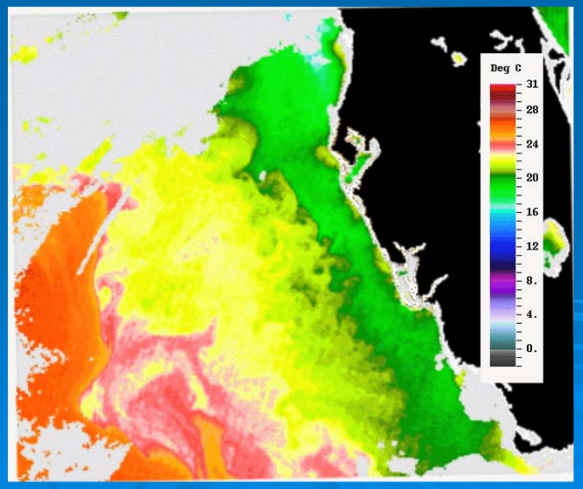
4. Develop and implement Technology to mitigate adverse effects from HABs

Monitoring, Modeling & Forecasting Essential for Mitigation & Control Strategy

Need to Know About HABs:

1. Location, Origin, Transport (physical)
2. Energy & nutrient sources (Chemical +)
3. Ecological Interactions (Bioloical +)
4. Termination processes (all of the above)

HAB Monitoring & Mitigation Technology



NOAA Satellite Temperature scan;
Change to Chlorophyll Scan

Innovative Technology Development to monitor & reduce red tide impacts.

Remote sensing technology for real-time monitoring

A. Vehicles for deploying sensing instrumentation.

- AUV: Autonomous Underwater Vehicle

- ROV: Remotely-Operated Underwater Vehicle
- ASV: Autonomous Surface Vessel

- Drones with Hyperspectral sensors (UAVs)

- Fixed location sensors on bouys, pilings & docks.

B. Sensing instrumentation for HAB Monitoring

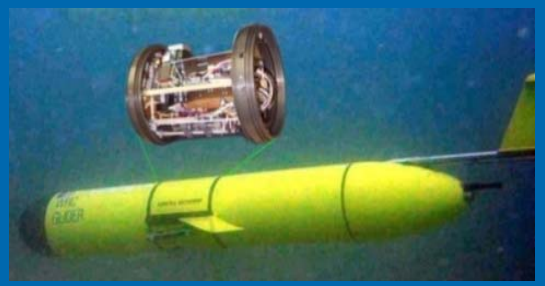
- **OPD; Optical Phytoplankton Discriminator**

Provides Similarity Index to identify HABs based on visible spectrum of specific phytoplankton species. Also provided CDOM, developed at Mote; Gary Kirkpatrick inventor

Two primary deployments:

- **Instrument package in the Teledyne-Webb Glider**

(Glider provides CTD & chlorophyll)
OPD-Requires high pressure valve & pumps for deep dives



- **Fixed location on bouy or channel marker poles.**

- Lower pressure housing for shallow water deployment

Programmable Hyperspectral Seawater Scanner (PHYSS; pronounced Fizz).

(Support from FWRI & GCOOS)

New generation, OPD replacement, with upgraded electronics & sensors:

G. Kirkpatrick, J. Hillier, K. Henderson, J. Turner, J. Beclker

- Fully programmable data acquisition process.

- Higher resolution spectrometer, better accuracy and sensitivity with ability to identify multiple phytoplankton groups.

- Web-based data analysis tool to review raw data from multiple operating systems.

Fixed location, shallow-water version

Future generation for deep AUV deployment

Drones with Hyperspectral Cameras for real-time monitoring of local areas

Real-time observation of the location and patchy nature of red tides

Red Tide patch off Mote Bay Dock
Mote File Photo from a Drone

- DJI Matrice 600 Pro

- **BaySpec OCI-F hyperspectral camera**
  - Continuous spectral and spatial coverage between 400-1000 nm (VIS-NIR)
  - 60 bands @ 10-12 nm per band
  - Ultra-compact - designed for small UAV systems

Courtesy of Vince Lovko

Other Innovative Monitoring Technologies

- ESP: The MBARI Environmental Sample Processor collection and analysis of water samples to identify organisms and/or toxins.

- IFCB: Imaging FlowCytobot, in situ automated flow cytometer provides high res HAB solution images for identification phytoplankton.

- NASBA: John Paul, USF-CMS; GCOOS; FWCC; Nucleic acid Sequence-based Amplifier, to identify HABs

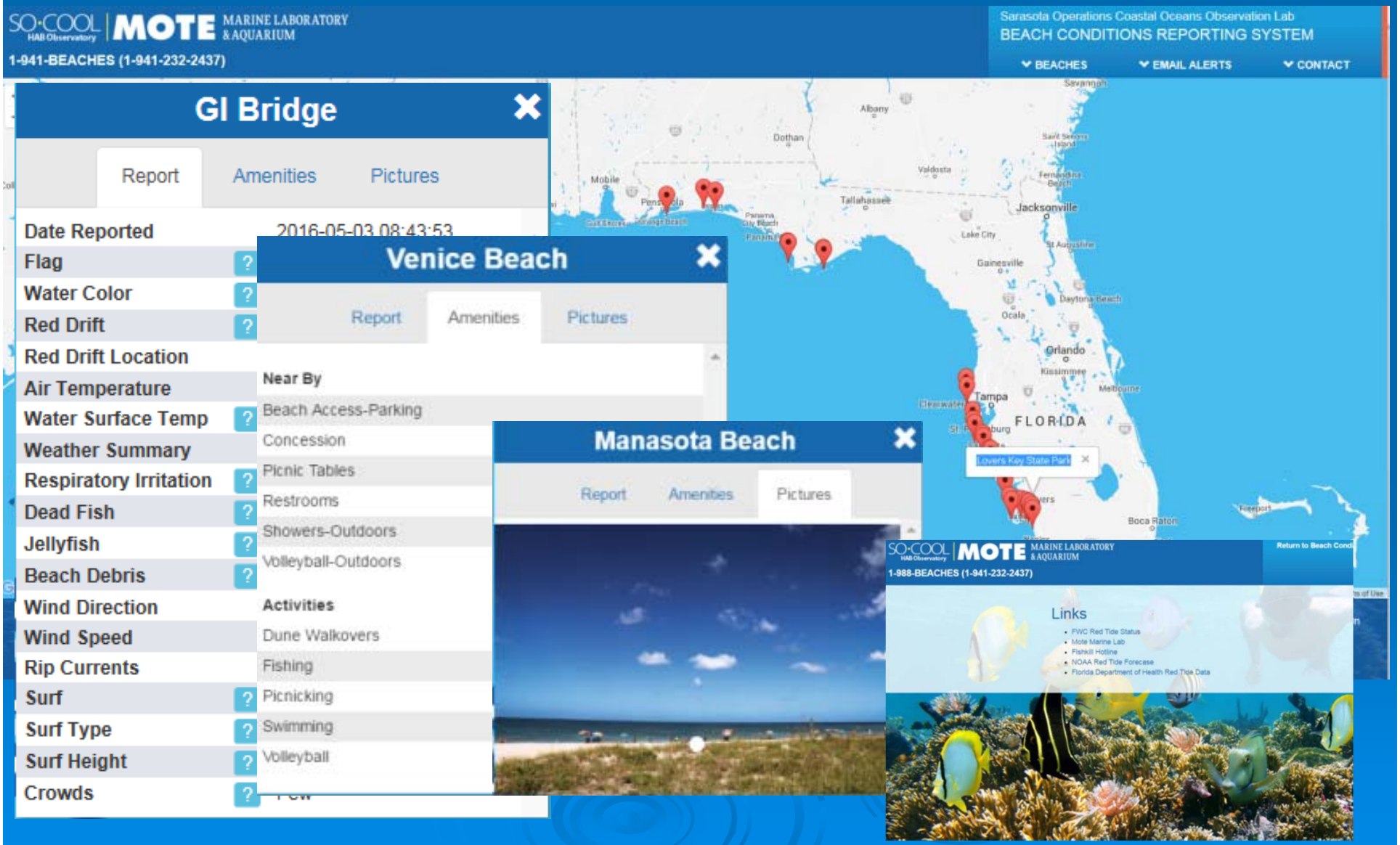
- Various Passive samplers for toxins which then are extracted and analyzed by Chromatography or ELISA methods.

- Satellite Instruments: MODIS – nFLH algorithm to detect phytoplankton blooms

- VIIRS: Visible & Infra red radiometer suite for phytoplankton detection

Beach Conditions Reporting System (BCRS)

VisitBeaches.Org



Mote Citizen Science Red Tide Reporting App.

(CSIC) Citizen Science Information Collaboation

Reporting by Anyone With a Cell Phone

Tracy Fanara & Vince Lovko

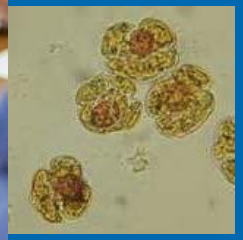
Courtesy of T. Fanara

c) Citizen Science: innovative reporting network to enhance real-time, wide spread, long-term data sets.

- **HABScope: NASA ROSES Program:**
  NOAA, GCOOS, Mote, collaboration

- **Improved Forecasts of Respiratory Illness Hazard from Gulf of Mexico Red Tide**
- **Microscope Camera interface for Red Tide Detection.**
- **Facial Recognition software for *K. brevis:***
  (R. Currier, GCOOS)
- **Quantifies BCRS Reports**
- **Provides frequent Predictions Of Respiratory Irritation**

Courtesy of T. Fanara & D. Buris



App by R. Currier, GCOOS

Red Tide Toxin Monitoring

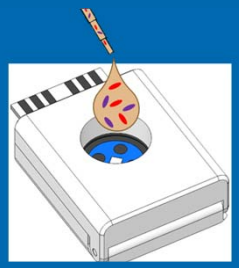
Aptamer-based electrochemical sensor:
Rapid assessment of brevetoxins in local areas
NOAA, Giner, Inc & Mote

Instrument: ***Wireless*** **operation** ***Hand-held*** **reader coupled to a** ***Disposable test cartridge***

Method: ***Proprietary electrochemical detection algorithms specific*** **for each target toxin**

Application: ***Electrochemical detection*** **of red tide toxins in seawater** ***below toxic threshold*** **levels**

Key Advantages: ***Rapid*** **(< 5 min)**
Cheap (< $15) field test
Long shelf life, **disposables**



1. Add sample to disposable cartridge

2. React for 5 min.

3. Insert cartridge into sensor

Current development status
PbTx-2 ≥ 0.25 µg/L
PbTx-3 ≥ 12.0 µg/L

Courtesy A. Argun, Giner, Inc.

Research for mitigation & Control of Adverse Effects from HABs

Biological Control

- **Parasite specific for HABs:**

Mario Sengco: Amoebophrya **is a syndinian endoparasite infecting a variety of dinoflagellate hosts, functions as a significant natural population control in some species.**
Red Tide Control & Mitigation Ptogram:

Phytoplankton Competition: Julia Kubanek: Researchers learned that many phytoplankton competitors (across taxonomic groups, including diatoms, cryptophytes, and dinoflagellates) can remove waterborne PbTx-2: Red Tide Control & Mitigation Ptogram:

- **Algicidal bacteria: Algicidal bacteria active against gymnodinium breve (dinophyceae) Bacterial isolation and Characterization of killing activity:** G.J. Doucette, E. R. McGovern J. A. Babinchak , August 2002; https://doi.org/10.1046/j.1529-8817.1999.3561447.x

Effects of macroalgae on the growth, survival and toxicity of *Karenia brevis*

Kayla Gardner[1], Hayley Richardson[2], Vince Lovko[3]
1. U. of South Carolina,; 2. U. of South Florida;
3. Mote Marine Laboratory

(Presentation at 9th US HAB Conference, 2017)

Results:

- ***Exposure to Dictyota, Gracilaria*, and *Acanthophora* species (separated by 7 micron mesh) resulted in 100% mortality of *K. brevis* within 4 days of exposure**

- **Brevetoxins were reduced by all species**

- **Exposure to filtrates (0.02 micron) of *Gracilaria sp.* resulted in 100% mortality and all other species significantly reduced the growth rate of *K. brevis* within 4 days**

Whole macroalgal exposure: Dual chambered flask with 7 micron mesh membrane in between the two

Living Dock / Mini-Reef Concept

Fouling organisms collected for water quality enhancement

FIT: Living Dock Deployment: September 30, 2017
Jennifer Mary Torres, FL Tech Happening, 9/7/2017. fit.edu

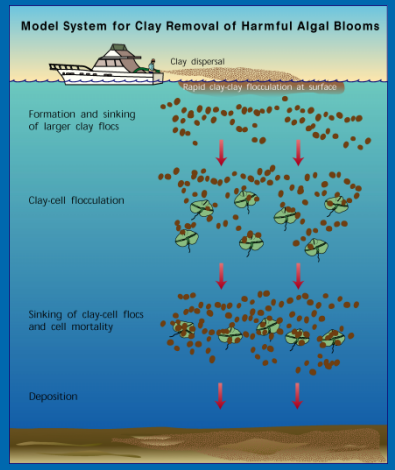
Mini-Reef: Artificial Reefs Create Habitat In Once-Barren Canal on Marco Island

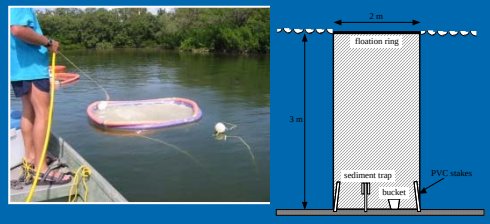
mini-reef dock in Marco Island.
Photo courtesy Ocean Habitats LLC

Mote: V. Lovko & T. Fanara
Investigating possible application for red tide control in canals and bays

Physical removal of HAB Cells & Toxins

Clay Flocculation Study in Sarasota Bay:
Mote, WHOI & NOAA, 2003-2005
P.Is: Mario Sengco, Don Anderson, Rich Pierce





Mesocosm pilot studies

Open water applications & monitoring during HAB in Sarasota Bay, FL

HAB (*Karenia brevis*) Fish Kill
Sarasota Bay, FL

Ozonation as On-Site Control & Restoration for Red Tide Impact

R. Pierce, L.K. Dixon, V. Lovko
Mote, START & FWRI & local Partners

Mote Patented Ozonation system used for Marine Mammal Hospital

Ozone is a strong oxidizing agent that kills red tide cells, degrades neurotoxins and re-oxygenates water.

- New application based on a patented, enclosed ozone contactor used for Mote Marine Mammal Hospital tanks, no ozone released into the ambient water

- **Pilot Studies with Raw water from New Pass, Gulf to Sarasota Bay.**

Mote 25,000 gal Mesocosm for ozonation Pilot tests

Raw water from New Pass Mesocosm pre-ozone ORP = 300 mv

Ozone treated Mesocosm ORP to 750 mv in 7 hrs

Pilot Studies Results:

1. Marine Mammal Hospital Tank studies:

- ORP 750mv destroyed *K. brevis* cells and toxins.
- No adverse effect on mammals or turtles

2. Mesocosm Pilot Studies:

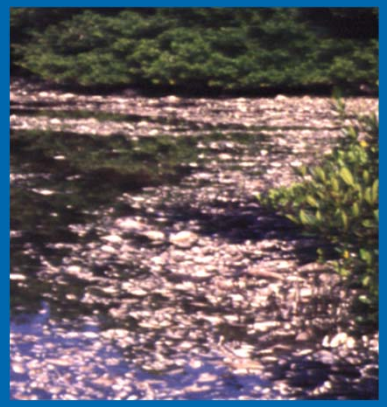
- 25,000 gal New Pass water reached 750 mv ORP in 7 hours (no HAB)
- No 72-hour acute toxicity to mysids exposed after ORP returned to ambient (~ 300 mv ORP)

3. Studies In progress:

- Assess inorganic nutrient residual,
- Assess acute and chronic toxicity

Ozonation as On-Site Control & Restoration for Mitigation of Red Tide Impacts

Testing Ozone Treatment Technology as a means to restore restricted areas that are severely impacted by red tide (dead marine organisms, oxygen depletion, putrid smell)



Restricted Flow Inlet

Residential Canal

- Applicable for residential canals, restricted flow inlets and marinas,

- Potential technology for shellfish protection and/or depuration.

Thank You