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Proceedings of the Harmful Algal Bloom (HAB) Preparedness & Response Virtual Workshop and Tabletop Exercise

Coastal Response Research Center

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Virtual Workshop and Tabletop Exercise

April 27 - 29, 2021

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II. Acronyms

ASPR	HHS Office of the Assistant Secretary for Preparedness and Response
BGATF	Florida Blue Green Algae Task Force
CAPT	Captain
CDC	U.S. Centers for Disease Control and Prevention
CFSAN	FDA Center for Food Safety and Applied Nutrition
CMAD	USEPA Consequence Management Advisory Division
CROW	Clinic for the Rehabilitation of Wildlife
CRRC	Coastal Response Research Center
DMAT	HHS NDMS Disaster Medical Assistance Teams
DMORT	Disaster Mortuary Operational Response Team
DPP	NOAA Disaster Preparedness Program
DRF	FEMA Disaster Relief Funds
DSS	FDA Division of Seafood Safety
ELISA	Enzyme-Linked Immunosorbent Assay
ERDC	USACE Engineer and Research Development Center
ESF	Emergency Support Function
USEPA	U.S. Environmental Protection Agency
FCO	Federal Coordinating Official
FDA	U.S. Food and Drug Administration
FEMA	U.S. Federal Emergency Management Agency
FLD	Fluorescence Detector
FLDEP	Florida Department of Environmental Protection
FWC	Florida Fish and Wildlife Conservation Commission
GCOOS	Gulf of Mexico Coastal Ocean Observing System
HAB	Harmful Algal Bloom
HABHRCA	Harmful Algal Bloom and Hypoxia Research and Control Act
HABITATS	USACE Harmful Algal Bloom Interception, Treatment, and Transformation System
HAEDAT	Harmful Algal Bloom Event Database
HHENS	HAB and Hypoxia Events of National Significance
HHS	U.S. Department of Health and Human Services
HPLC	High Performance Liquid Chromatography
IAA	Inter-Agency Agreement
IOC	Intergovernmental Oceanographic Commission
IPHAB	Intergovernmental Panel on Harmful Algal Blooms
ISSC	Interstate Shellfish Sanitation Conference
IVLE	Intravenous Lipid Emulsion
IWG-HABHRCA	Interagency Working Group on the Harmful Algal Bloom and Hypoxia Research and Control Act
IC-MS-MS	Liquid Chromatography – Tandem Mass Spectrometry
LO	Line Office
MRC	HHS Medical Reserve Corps

NARS	USEPA National Aquatic Resource Surveys
NCCOS	NOAA National Centers for Coastal Ocean Science
NCEH/ATSDR	CDC National Center for Environmental Health/Agency for Toxic Substances and Disease Registry
NDMS	HHS National Disaster Medical System
NIEHS	National Institute of Environmental Health Sciences
NLA	USEPA National Lakes Assessment
NOAA	U.S. National Oceanic and Atmospheric Administration
NORS	CDC National Outbreak Reporting System
NOS	NOAA National Ocean Service
NPS	U.S. National Park Service
NSF	U.S. National Science Foundation
NSP	Neurotoxic Shellfish Poisoning
NSSP	National Shellfish Sanitation Program
NVRT	HHS National Veterinary Response Teams
OAR	NOAA Office of Oceanic and Atmospheric Research
ORD	USEPA Office of Research and Development
OR&R	NOAA Office of Response and Restoration
OHHABS	CDC One Health Harmful Algal Bloom System
PST	Paralytic Shellfish Toxins
RDF	ASPR Rapid Deployment Force
RSF	Recovery Support Function
SDWA	Safe Drinking Water Act
SNS	HHS Strategic National Stockpile
UCMR	Unregulated Contaminant Monitoring Rule
UNESCO	IOC – United Nations Educational, Scientific, and Cultural Organization
UNH	University of New Hampshire
U.S.	United States
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	United States Geological Survey
USPHS	U.S. Public Health Service
UV	Ultraviolet
WoRMS	World Register of Marine Species

III. Acknowledgements

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- Nancy Kinner, CRRC, University of New Hampshire (UNH)
- Charles Grisafi, NOAA OR&R DPP
- Katherine Krushinski, NOAA OR&R DPP
- Tony Marshak, NOAA National Centers for Coastal Ocean Science (NCCOS)
- Mary Kate Rogener, NOAA NCCOS
- Jennifer Graham, U.S. Geological Survey (USGS)
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- Stacey Wiggins, U.S. Food and Drug Administration (FDA) Center for Food Safety and Applied Nutrition (CFSAN) Division of Seafood Safety (DSS)
- Joselito Ignacio, U.S. Federal Emergency Management Agency (FEMA)
- Katie Perry, CRRC, UNH

This workshop was facilitated by Nancy Kinner (www.crrc.unh.edu). CRRC is known globally as an independent, intermediary that brings all stakeholders to the table to develop and implement viable and trusted solutions to complex problems related to environmental disasters. CRRC has conducted 70+ workshops that bring together practitioners, researchers, and scientists of diverse backgrounds (e.g., industry, academia, government, NGOs) to discuss and develop solutions to marine pollution and disaster problems.

We would like to thank each of the speakers and poster presenters for their participation in the workshop:

- Dave Kidwell, NOAA NCCOS and IWG-HABHRCA Co-Chair (acting)
- Deborah Nagle, USEPA Office of Science and Technology, Office of Water and IWG-HABHRCA Co-Chair (acting)
- Kaytee Boyd, NOAA NCCOS HAB Forecasting Branch
- Fred Tyson, National Institute of Environmental Health Sciences (NIEHS) Division of Extramural Research and Training, Genes Environment and Health Branch
- Mike Higgins, U.S. Fish and Wildlife Service (USFWS) National Wildlife Refuge System

- Danielle Buttke, U.S. National Park Service (NPS) Biological Resources Division and Office of Public Health
- CAPT Renee Funk, CDC National Center for Environmental Health/Agency for Toxic Substances and Disease Registry (NCEH/ATSDR)
- Leremy Colf, U.S. Department of Health and Human Services (HHS) Office of the Assistant Secretary for Preparedness and Response (ASPR)
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- Vera Trainer, NOAA Fisheries
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- Barb Kirkpatrick, Gulf of Mexico Coastal Ocean Observing System (GCOOS)
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- Christina Saltus, USACE
- Erich Emery, USACE
- Timothy Wynne, NOAA NCCOS
- Mary Kate Rogener, NOAA NCCOS

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IV. Executive Summary

On April 27 - 28, 2021, CRRC and DPP co-sponsored a virtual workshop entitled "Harmful Algal Bloom (HAB) Preparedness & Response." The workshop focused on HAB preparedness and response capabilities and responsibilities across the Federal Interagency Working Group on Harmful Algal Bloom and Hypoxia Research and Control Act (IWG – HABHRCA) member and select state agencies. See **Appendix A** for the workshop agenda. Workshop participants represented academia, Federal, state, and local agencies. Presentation summaries can be found in the section entitled "Plenary Presentations." Presentation slides are in **Appendix B.**

Following the workshop, CRRC and DPP conducted a half-day virtual tabletop exercise on April 29, 2021, entitled "Fresh and Salty: The Story of a HAB." The exercise focused on understanding the resources, expertise, capabilities, roles, and responsibilities of IWG-HABHRCA Federal agencies and select state agencies related to a HAB event. Additionally, the exercise facilitated discussions on current plans, policies, and procedures in-place to effectively manage a cross-agency, coordinated response. The exercise, broken into two modules, centered on a hypothetical hurricane that made landfall in the Galveston, TX region. In the first module, Freshwater Response, the conceived storm created an influx of freshwater and nutrients resulting in a cyanobacterial bloom in a hyposaline environment subject to freshwater input. The second module, Marine Response, expanded upon the Freshwater Response module as the freshwater cyanobacterial bloom was transported southward into the Gulf of Mexico, requiring a marine HAB response. Participants were divided into five breakout groups to discuss pre-determined questions in each module followed by a group discussion. Specific details related to the tabletop exercise scenario and modules are included in the Situation Manual (**Appendix C**). The exercise allowed for different agency representatives to share their agencies' resources, expertise, capabilities, roles, and responsibilities. Federal agencies discussed specific plans, procedures, and guidance documents to assist in a cross-agency response. These discussions revealed current gaps in HAB preparedness and response efforts, including:

- A lack of shared information within Federal agencies and between select state agencies;
- No established process to recruit the assistance of non-mandated Federal agencies in a HAB response;
- Many gaps identified related to existing plans, policies, and procedures used to effectively manage a cross-agency, coordinated HAB response; and
- Uncertainty regarding the communication channels and procedures of sharing information between Federal, state, and local agencies and the public.

The overall goal of this workshop and subsequent tabletop exercise was to provide a focused discussion to enhance preparedness across the IWG – HABHRCA members and its partners.

Specific objectives were to better understand:

1. The roles and responsibilities of different Federal agencies involved in HABs;
2. The science and tools that help drive decision-making; and
3. The importance of interagency coordination for improved HAB management and response in the U.S.

The two-day workshop included plenary presentations from Federal, state, and non-government agency representatives outlining: their roles and responsibilities; risk and crisis communication strategies; tools for early detection, measurement quantification, and mitigation; and public health and wildlife impacts. The outcomes and suggested action items are outlined in Section VI Workshop Outcomes and in the After-Action Report (**Appendix D**).

V. Workshop

A. Introduction

Prior to the workshop, participants were encouraged to watch two informational videos to learn about the impacts of marine and freshwater HABs. The videos are:

1. ***Many HABs, Many Impacts (Marine),*** by Quay Dortch, Senior HAB Scientist, NOAA NCCOS
2. ***CyanoHABs – Global Problem with Regional and Socio-Economic Impacts (Freshwater),*** by Timothy Davis, Professor, Bowling Green State University

Poster presentations were available for viewing throughout the workshop on the workshop webpage (https://crrc.unh.edu/workshop/HAB). The posters were:

Title: *Harmful Algal Bloom Indicator Estimation in Small Inland Waterbodies: Remote Sensing-Based Software Tools to Assist with USACE Water Quality Monitoring*
Authors: Molly Reif (molly.k.reif@usace.army.mil), Richard Johansen, Christina Saltus, and Erich Emery
Affiliation: U.S. Army Corps of Engineers

Title: *NCCOS Harmful Algal Bloom Forecasting Capabilities: Research to Operations*
Authors: Kaytee Pokrzywinski-Boyd (kaytee.boyd@noaa.gov) and Timothy Wynne
Affiliation: NOAA National Centers for Coastal Ocean Science

Title: *NCCOS Harmful Algal Bloom Event Response Program*
Authors: Mary Kate Rogener (marykate.rogener@noaa.gov)
Affiliation: NOAA National Centers for Coastal Ocean Science

B. Plenary Presentations Day 1

Overview of Federal Response to HABs

David Kidwell, NOAA, IWG Co-Chair (acting) discussed Congressional legislation related to HABs, including the authorization of the Harmful Algal Bloom and Hypoxia Research and Control Act (HABHRCA) in 1998 that was amended in 2004, 2014, and 2019. The 2004 reauthorization expanded the mandate for NOAA to coordinate and develop action plans and implementation strategies on HABs and hypoxia events in the United States. The 2014 revision gave USEPA the responsibility to study, forecast, and monitor event response for freshwater HAB events and established the Interagency Working Group (IWG). The terminology HAB and Hypoxia Events of National Significance (HHENS) was established in the 2019 revision.

The IWG-HABHRCA, chaired by NOAA, USEPA, and the White House Office of Science and Technology Policy (OSTP), serves as a coordinating body between Federal agencies and their stakeholders to discuss HAB event preparation and response. Kidwell described IWG-HABHRCA

reports that were published and transmitted to Congress, including the *Harmful Algal Blooms and Hypoxia Comprehensive Research Plan and Action Strategy* (2016), *Harmful Algal Blooms and Hypoxia in the Great Lakes Research Plan and Action Strategy* (2017), *Harmful Algal Blooms and Hypoxia in the United States: A Report on Interagency Progress and Implementation* (2018), and *Harmful Algal Blooms and Hypoxia in the Great Lakes: An Interagency Progress and Implementation Report* (2020).

Kidwell used examples to describe how different Federal agencies collaborate on HAB event response. One example is the ongoing *Pseudo-nitzschia* bloom off the U.S. west coast where USEPA, NOAA, and FDA have worked together providing monitoring and analysis capabilities to enhance the ability of local communities to respond.

Kidwell gave examples of different agency efforts related to HABs. CDC funds multiple states to develop programs for responding to HAB-related public health issues. FDA assists states with sample collection and analysis when marine biotoxins are suspected in state waters and is the primary responder to blooms in Federal waters pertaining to food safety. NOAA has multiple programs involved in HAB response including: the HAB Event Response Program, Marine Mammal Health and Stranding Response Program, Analytical Response Team, and HAB Forecasting and Monitoring. NPS has a HAB response database used to inform park managers. USACE has response programs, developed by individual USACE Divisions/Districts, that coordinate with state water quality and public health agencies. USGS National Wildlife Health Center is mandated for HAB response and provides sample handling and project coordination for investigating wildlife disease and mortality events. Kidwell concluded by describing ongoing and future research and development priorities for HAB response and monitoring.

Federal Agency Presentations

Deborah Nagle, USEPA gave an overview of USEPA's mission and general responsibilities. USEPA has jurisdiction over freshwater HAB and hypoxia events. USEPA provides funding to the Great Lakes, Gulf of Mexico, and national estuaries to reduce excess nutrients that may contribute to HAB events. Nagle discussed how the agency promotes monitoring and conservation initiatives and supports effective strategies to reduce cyanotoxins in source water used as a source for drinking water. USEPA provides satellite-derived water quality information to help states and tribes forecast HAB events. USEPA has publicly available resources for HAB event response focused on monitoring, risk communication strategies, laboratory analysis, and management of cyanotoxins in recreational waters and drinking water systems. They use the Unregulated Contaminant Monitoring Rule (UCMR) to collect data for contaminants that may be found in drinking water and are not regulated under the Safe Drinking Water Act (SDWA). Between 2018 and 2020, USEPA monitored for ten cyanotoxins in public drinking water systems and the preliminary data is posted on USEPA's UCMR website. The agency monitors for cyanotoxins and cyanobacteria indicators in lakes, rivers/streams, coastal waters, and wetlands through the National Aquatic Resource Surveys (NARS). These monitoring efforts allow them to observe the occurrence of cyanotoxins in freshwater bodies and track trends. For example, the National Lakes Assessment (NLA) found a >9 % increase in detected microcystins in U.S. lakes between 2007 and 2012.

Nagle briefly discussed USEPA's Office of Research and Development (ORD), which conducts HAB research. ORD's short term research projects include quantifying toxins in fish tissue and advancing drinking water treatments. Long term research goals for this office include understanding bloom dynamics on the cellular level and reducing excess nutrient loading into water bodies.

Kaytee Pokrzywinski-Boyd, NOAA presented on NOAA's HAB event response capabilities and research. NOAA primarily conducts HAB research across three Line Offices (LOs): 1) Oceanic & Atmospheric Research (OAR), 2) National Ocean Service (NOS), and 3) NOAA Fisheries. Each LO is uniquely suited to address different areas of concern regarding HABs. OAR conducts coastal and Great Lakes research and monitoring for HABs and water quality. NOS conducts research for observing and forecasting systems, and studies interactions with state and tribal partners. NOAA Fisheries conducts research on shellfish biotoxins, marine mammals and protected species, and examines tribal interactions. Pokrzywinski-Boyd discussed how these and other NOAA LOs collaborate to ensure that the best available products and tools are available for early warning systems during a HAB event.

NOAA supports HAB event response by: 1) providing financial support to rapidly mobilize and respond to an event, 2) providing technical resources and expertise for analytically supporting event response programs, and 3) identifying leveraging opportunities to support Regional Specific Responses. Pokrzywinski-Boyd used previous HAB events to illustrate NOAA's immediate response actions including using satellite imagery, identifying HAB species, analyzing toxin samples, and determining the cause of marine mortality events. NOAA has a variety of resources, funding programs, and technical expertise to support immediate response efforts.

Frederick Tyson, NIEHS discussed the mission of NIEHS and its three strategic goals for environmental health science: 1) advancing environmental health sciences, 2) translating data knowledge into action, and 3) enhancing scientific stewardship and support. NIEHS supports research on marine HAB and freshwater cyanobacterial toxins. Tyson described the research methods NIEHS scientists use to identify HAB toxins, the mechanisms of toxicity, and their associated human health outcomes. Examples of research methods include the deployment of deep ocean sensors, satellite imagery, and the development of novel prediction algorithms. NIEHS also engages stakeholders from vulnerable communities and citizen scientists during HAB events.

NIEHS has an ongoing collaboration with the National Science Foundation (NSF). Tyson described HAB-related research grants under the NSF partnership, including the Oceans and Human Health funding program, and other independent NIEHS research grants. Tyson concluded by providing an overview of the NIEHS training programs that engage and train the next generation of HAB scientists.

Michael Higgins, USFWS introduced the mission of the agency and relevant program areas that have been or might be involved in HAB response. USFWS is not mandated to respond to HAB events. However, they must protect wildlife populations and habitats for which they have jurisdiction. If a HAB event occurs on a National Wildlife Refuge it can impact the wildlife, visitors, pets, employees, and domestic animals (e.g., livestock). National Wildlife Refuges with reoccurring HAB events include those in Florida, North Carolina, North and South Dakota, the Midwest, Lake

Erie, and on the West Coast. Higgins stated that HAB events are occurring more frequently, starting earlier in the season, and span a larger geographical area than in previous years.

The Wildlife Health Office of the National Wildlife Refuge System prepares for HAB events by providing educational materials, increasing awareness among employees, conducting outreach to visitors and adjacent landowners, providing water sampling kits and guidance, and arranging laboratory analysis of water/tissue samples. HAB events can co-occur with other mortality events (e.g., botulism) that, coupled with the lack of toxicity endpoint data, make it difficult to assign mortality to the HAB event.

Danielle Buttke, NPS discussed how NPS prepares for HAB events and response challenges. NPS is a Federal land management agency that does not have a dedicated program for HAB response. They use partnerships to conduct research and improve response and always encourage the development of new partnerships. The peak of HAB season often corresponds to when NPS lands have the most visitors. Buttke described the challenges with this overlap stating that there is a lag between the time when a visitor gets exposed and when information is reported back to the NPS Office of Public Health for investigation. Additionally, the health care provider is often in a different location than where the HAB event occurred.

For HAB response, NPS is typically involved during wildlife die-off events (e.g., green tree frog die-off), visitor dog deaths, and human illnesses (e.g., rash, suspected neurologic disease). As HAB events become more frequent, NPS has increased monitoring efforts in recreational waters, drinking water systems, and fish and shellfish. Currently, NPS is working with USGS to develop methods to support citizen science, visual monitoring, and other ways to inform when to collect samples, close park areas, and place warning signs. NPS is also educating the public on shellfish advisories and how to interpret them. Buttke described ongoing research within NPS from the Biological Resource, Air Resources, and Water Resources Divisions.

Jennifer Graham, USGS introduced the mission of USGS and presented their ongoing HAB research. USGS does not have a congressional mandate for HAB response. HAB efforts at USGS are focused on:1) developing field and laboratory methods to identify and quantify HABs and associated toxins; 2) understanding occurrence, causal factors, environmental fate and transport, ecological processes, and effects of environmental exposure; and 3) developing tools to inform management decisions. Graham discussed four USGS laboratories and their role in HAB research: 1) USGS Algal and Other Environmental Toxins Laboratory, 2) USGS Michigan Bacteriological Research Laboratory, 3) USGS Ohio Water Microbiology Laboratory, and 4)National Water Quality Laboratory.

Graham also discussed the mission, services, and resources of the USGS National Wildlife Health Center and their mandate to respond to wildlife mortality events. USGS has online tools and resources that are used as part of HAB research and could be used for event response, such as the National Water Dashboard interactive tool and the USGS Earth Explorer database. During a response, USGS scientists provide technical expertise and occasionally will assist with data collection.

USGS has several programs focused on HAB research, including: The Toxins and Harmful Algal Blooms Science Team, which is developing advanced methods to identify factors driving algal toxin production, understanding how and where wildlife or humans are exposed to toxins, and developing decision-making tools. The Next Generation Water Observing System is working to integrate fixed and mobile monitoring assets in the water, ground and air including integrative webcams and ground-to-space sensors. Harmful Algal Bloom Cooperative Matching Funds Projects support joint studies with partners to provide reliable, impartial, and timely information to understand and manage water resources. There are currently 24 USGS Harmful Algal Bloom Cooperative Matching Funds projects that cover 15 geographical areas. Projects include using remote sensing and molecular technology to identify and predict the occurrence of HAB events and the toxins they produce.

Tony Clyde, USACE provided an overview of the lands and recreation areas that USACE manages. USACE civil works projects primarily focus on flood risk management, recreation, water supply, and fish and wildlife. USACE typically addresses cyanobacteria blooms that impact entire waterbodies, only coves/shorelines, or a mixture of both. HAB events on USACE managed lands impact Lake Office Operations and staff. Subsequently, they submit requests for operational changes, increased monitoring, assistance with public outreach, and closures/advisories. Clyde explained that the public often expresses concerns related to economic impacts, negative social media and news coverage, pet illnesses and deaths, and human illnesses.

USACE districts can submit research and development statements of need or request technical support for water operations to the ERDC. Clyde gave an overview of recent technical support requests at the district level and statements of need submitted by the districts to ERDC on HABs. Multiple tools have been derived from these programs to assess the impact of HABs at reservoirs. In recent months, USACE has responded to HAB events in three districts (Seattle, Fort Worth, and Mobile) in addition to open water planktonic HAB events. Clyde concluded by reviewing HAB-driven legislative requirements such as the WRDA 2018 (PL 115-270) Sec. 1109 Harmful Algal Bloom Technology Demonstration and the WRDA 2020 (PL 116-133) Sec. 128 Harmful Algal Bloom Demonstration Project.

Renée Funk, CDC discussed how CDC responds to environmental health hazards. They are activated for response actions under the Emergency Support Function (ESF) 8: Public Health and Medical Services. CDC coordinates the public health component of ESF 8, and ASPR facilitates the medical services component. Under ESF 8, the agency provides assistance to state, tribal, and local governments. Funk described how CDC response activities could be applied to HAB event response. CDC could deploy epidemiology and health services such as media mortality tracking, shelter surveillance, community needs assessments, syndromic surveillance, and technical support to state and local health departments. Additionally, they can aid in protecting environmental health by coordinating private and public water system issues, vector control, and monitoring occupation health. Lastly, they could help disseminate timely and accurate information, track news and social media reports, rumor control, and partner messaging. Funk concluded by describing the unique aspects of responding to environmental emergencies. Where there is a wide range of health and safety concerns requiring different expertise and coordination with health and non-health partners in addition to specific response-related challenges.

Stacey Wiggins, FDA presented FDA's roles and responsibilities related to HAB preparedness and response. Wiggins gave an overview of FDA's mission and HAB responsibilities related to the toxins that HABs produce and the potential for those toxins to impact food. Marine toxins of interest to FDA include those that may cause paralytic, neurotoxic, amnesic, azaspiracid, and diarrhetic shellfish poisoning. Toxins known to be produced by freshwater cyanobacteria include neurotoxins, dermatoxins, hepatotoxins and gastrointestinal toxins.

The FDA-regulated products that have the potential to be impacted by marine and/or freshwater toxins include seafood, bottled water, produce in contact with irrigation water, water for food processing, and dietary supplements. Wiggins reviewed relevant Federal regulations that FDA applies when managing products with potential toxin exposure. FDA has established guidance levels for certain biotoxins in seafood.

Wiggins explained that molluscan shellfish are the primary commodity impacted by HAB toxins. Molluscan shellfish are regulated through a program called the Interstate Shellfish Sanitation Conference (ISSC). The ISSC is a cooperative body comprising Federal, state, and academic partners that work together to foster and promote shellfish sanitation. The ISSC manages the National Shellfish Sanitation Program (NSSP) which is a cooperative program for the control of shellfish produced and sold in interstate commerce for human consumption. The NSSP develops a Guide for the Control of Molluscan Shellfish that is revised approximately every two years through a proposal process. It includes guidance and the Model Ordinance, which may be adopted as a regulation by the states.

FDA places emphasis on control and prevention efforts during HAB events so that seafood toxin levels do not meet or exceed the established FDA guidance levels available in interstate commerce. One example of prevention is for states to place shellfish growing areas in the closed status when biotoxin concentrations reach or exceed the guidance levels. Wiggins explained that if molluscan shellfish contamination occurs, FDA assists in communicating with states, Federal partners, and the ISSC. FDA monitors product recalls, provides technical assistance, and ensures that states follow appropriate reopening criteria when the HAB event (including toxins in shellfish) is no longer an issue.

The FDA Division of Seafood Safety's strategic plan focuses on four goals: 1) assessing and evaluating newly identified potential seafood hazards; 2) identifying strategies to improve the control of seafood contamination; 3) developing systematic approaches for monitoring incidence of contamination; and 4) strengthening relations with international, Federal, state, local, tribal, and territorial agencies. Wiggins concluded by discussing an initiative at FDA called the New Era of Smarter Food Safety. One goal of this program is strengthening predictive analytics capabilities. The strategic plan and the New Era of Smarter Food Safety initiative are well aligned with the specific goal of predicting and preventing impacts to molluscan shellfish associated with HAB events.

Joselito Ignacio, FEMA's Public Health Advisor within the Office of Response and Recovery in the Response Directorate gave an overview of the agency's mission and responsibilities. FEMA's role is to effectively manage the efficient and timely delivery of Federal disaster relief to support and supplement the efforts and capabilities of state, tribal, territorial, local, and insular area

governments; eligible nonprofit organizations; and individuals affected by a declared major disaster or emergency.

In a Stafford Act Emergency/Disaster Declaration, the supported entity is the state, tribal, territorial, and local jurisdictions using Disaster Relief Funds. FEMA has the authority under the President and through a designated Federal Coordinating Official (FCO) to assign various Federal departments and agencies based on resource requests from the impacted entity.

A Stafford Emergency Declaration, is any occasion or instance for which, in the determination of the President, Federal assistance is needed to supplement state and local efforts and capabilities to save lives, and to protect property and public health and safety or to lessen or avert the threat of a catastrophe in any part of the U.S. FEMA assistance is normally unmandated or short term and less than $5 million to save lives and protect public health, safety, and property. A Major Disaster Declaration involves those events that cause damage of sufficient severity and magnitude to warrant major assistance under the Stafford Act to supplement efforts and available resources of states, local government, and disaster relief organizations. FEMA assistance usually exceeds $5 million and will trigger the use of disaster assistance and grant programs, individual assistance to impacted individuals or households, public assistance, and hazard mitigation assistance (which is aimed at developing measures to strengthen the communities against similar disasters in the future).

In a non-Stafford, the process is initiated by an incident, and a lead Federal Agency is supporting impacted state, tribal, territorial, and local jurisdictions under that agency's legislative authorities. If the event is not declared a Stafford event, a series of questions is asked: 1) does the state, tribal, territorial, and local need support? And 2) can the lead Federal Authority provide the support? The lead Federal Authority can request support from other Federal departments and agencies, like FEMA.

If a non-Stafford event occurs then FEMA's involvement may occur through an interagency agreement with the designated lead Federal Agency or authority whose legislative responsibilities are aimed at a particular incident response, such as HAB. Here, FEMA cannot assign any Federal department or agency, and the lead Federal Agency must establish separate interagency agreements with those other Federal department/agencies, as appropriate.

Each Federal department and agency have inherent authorities to respond to certain incidents. USDA, for example, has authorities to respond to large-scale animal disease outbreaks in support of the impacted state, tribal, territorial, and local jurisdictions. Once a Presidential Declaration (an emergency or major disaster declaration) occurs, the President will delegate those authorities to the DHS Secretary, who is responsible for overall coordination of the Federal response. FEMA leads the Stafford Act activities required under law through a designated Federal Coordinating Official.

FEMA can play a role in supporting impacted communities (through Stafford Emergency/Disaster Declaration) or in a non-Stafford arrangement, support the designated lead Federal Authority in a HAB event.

Leremy Colf, HHS ASPR discussed that ASPR does not have statutory authority for HAB response but can support state, local, tribal, and territory responses to public health and medical events. Colf reviewed previous Stafford Act and Public Health Emergency declarations related to HAB events and noted one in Maine in 1972 and a second in Massachusetts in 1980; both declarations appear to be related to fishing losses due to toxic algae in coastal waters. Since these events did not have major medical consequences, ASPR support was not requested. However, if a HAB event occurs and warrants a Public Health Emergency declaration or Stafford Act declaration, ASPR could potentially respond.

Colf provided and overview of ASPR's mission, noting that they frequently work with CDC and FEMA. ASPR oversees two main response/recovery areas 1) ESF 8: Public Health and Medical Services, and 2) Recovery Support Function (RSF) 3: Health and Social Services. Colf described select response resources used to support local and state responses. The National Disaster Medical System (NDMS) is a federally coordinated disaster healthcare resource. Within the NDMS is the Disaster Medical Assistance Teams (DMAT), Disaster Mortuary Operational Response Team (DMORT), and the National Veterinary Response Teams (NVRT). The Medical Reserve Corps (MRC) is a national network of volunteer units that can support state and local health department responses to disasters in their communities. The Strategic National Stockpile (SNS) contains Push Packages designed to protect the public if local medical supplies run out. The U.S. Public Health Service (USPHS) is a commissioned corps that has a mental health team and a Rapid Deployment Force (RDF) team.

Colf discussed the ASPR National Healthcare Preparedness Program which strengthens health care preparedness at the local, state, and regional levels through collaboration among healthcare and public health entities.

Compare and Contrast the 2016 Lake Okeechobee Response to Current HAB Responses

Dave Whiting, Florida Department of Environmental Protection compared that state's current HAB response practices to those used in the 2016 bloom season involving Lake Okeechobee. That year, Florida had record rainfall causing higher water levels and excess nutrients, delivered through runoff which caused a large bloom in the lake. As water levels rose, USACE had to release water from Lake Okeechobee to maintain the structural integrity of the Herbert Hoover Dike. Most of the contaminated bloom water was released to the Caloosahatchee and St. Lucie River systems that lead to estuaries. The released water and algal biomass moved through the system more intensely on the St. Lucie River with weather patterns packing large amounts of algal biomass into dead end canals and marinas.

Currently, USACE has operational flexibility as to when they release water to help avoid large impacts of bloom water from Lake Okeechobee. Non-bloom water is released during cooler months to provide capacity to hold water during bloom season. Additionally, FLDEP and USACE piloted innovative technologies at the S308/C77 structures in 2020 to treat discharge water as needed.

During the 2016 bloom season, FLDEP created an algal bloom information page that provided: reporting hotline and webpage, cyanoHAB frequently asked questions, sampling results, information on innovative clean-up technology evaluations, beach closures, human health and

wildlife impacts, and response team contact information. Currently, the algal bloom dashboard provides public access to large amounts of information and data. During a bloom, all sample results are posted to FLDEP's algal bloom dashboard and the Florida Department of Health reviews it daily and contacts local county health departments. Caution signs are used when cyanobacteria are present, but toxins are not detected. Health alert signs are used when toxins are detected. The Florida Department of Health sends daily emails regarding cyanobacteria results including a table to help local health departments with decision-making.

In 2016, NOAA was not providing daily 300-meter resolution imagery of South Florida as they do now. Currently, daily imagery is available for the lakes and estuaries in Florida prone to HAB events.

Whiting described previous cyanobacterial blooms that had been self-resolving, without the need for removal or treatment of biomass. In 2016, there were no established clean-up contracts and companies began demonstrating their technologies without being reviewed and approved. FLDEP, with the assistance of other Federal and state agency staff, reviewed a wide range of clean-up and mitigation technologies and established contracts with two companies specializing in biomass removal and ozonation.

Another outcome of the 2016 HAB event was the formation of the Blue Green Algae Task Force (BGATF) in 2019. The task force produced its first consensus document in 2019, which included recommended best practices for basin management action plans, agriculture, human waste, stormwater treatment, public health, and monitoring needs.

Whiting discussed current bloom thresholds and management practices. The Florida Department of Health uses the presence of potential toxin-producing cyanobacteria and detection of any level of cyanotoxins as health notification thresholds instead of a numeric toxin threshold value. They advise the public to avoid recreating and allowing pets or livestock in waters with visible algae present.

FLDEP will not be adopting USEPA's recommended cyanotoxin thresholds for recreational waters but will explore adopting more scientifically defensible criteria in the future. USEPA's recommended thresholds are based on incidental ingestion by children during normal recreational activity and do not account for any other exposure routes (i.e., inhalation, dermal, fish/shellfish consumption). Whiting concluded by summarizing the efforts that Florida has taken since 2016 to improve HAB preparedness, coordination, communication, and response.

2018 Florida Red Tide Case Study: Scientific and Communication Response

Kate Hubbard, Florida Fish and Wildlife Conservation Commission discussed the 2018 Florida red tide event, focusing on Florida's scientific and public communication response efforts. Red tide is caused by the toxic marine dinoflagellate, *Karenia brevis*. Brevetoxins, produced by *K. brevis*, can accumulate in shellfish, and cause Neurotoxic Shellfish Poisoning (NSP) in humans. These toxins can also be aerosolized in sea spray, causing respiratory irritation, and can kill wildlife. They can also cause numerous economic impacts related to tourism, public health, and cleanup costs associated with fish kills on beaches. Red tide blooms were first identified in Florida in

the 1800's. There have been red tide events in southwest Florida nearly every year since the state started testing more regularly in 1953. The longest documented bloom in Florida since then was 30 months.

The recent 2017 to 2019 severe red tide event was 16 months long, with its peak in 2018. This bloom impacted southwest, northwest, and east Florida. During a normal season, before this event, about 150 samples would be collected per week. At the peak of this red tide, ~ 150 samples were submitted daily. Hubbard explained that red tides can be spatially patchy, with different concentrations within a short distance.

This red tide started in November 2017 and extended through Florida's wet season, when new red tide initiation starts, and ocean conditions are appropriate to bring new cells onshore. In 2018, Tropical Storm Gordon may have played a role in transporting cells upward towards Florida's Panhandle. Shortly after, Hurricane Florence passed Florida and cells started to be observed in new locations across the state. In October 2018, Hurricane Michael hit Florida and likely intensified the red tide in the Panhandle. This made sampling difficult because most efforts in the region were focused on hurricane response.

Hubbard described the use of remote sensing and gliders to map the subsurface water column in the offshore initiation zone. A glider was working and sampling off in the Tampa Bay area, collecting chlorophyll and temperature data. The data showed that chlorophyll was found far offshore leading scientists to wonder if there was an ongoing new supply of cells at depth. Physics data suggested that it was a possibility, and cells were observed offshore at depth, but the active storm season and preceding bloom made it difficult to confirm the ultimate source of these cells.

Hubbard described the impacts of the 2018 red tide event. NOAA declared an unusual marine mammal mortality event due to more than 200 dolphin strandings. Over 500 sea turtle strandings and more than 300 manatee mortalities were also reported. There were over 1,500 reports and requests for information for FWC's fish kill hotline, over 100 fish species were impacted, and counties had to clean-up hundreds of tons of fish. The Governor directed $13 million to assist local communities with clean-up and response. There were fisheries closures for three species, and multiple shellfish harvest area closures. Heavily impacted areas included: Charlotte Harbor, and Gasparilla Sound. Charlotte Harbor is one of the most productive areas for shellfish aquaculture in Florida and had two long-lasting closures. Gasparilla Sound had closures that lasted for 21 months. Some of the fishery's closures are still in place as of April 2021.

Communication was critical during and after this event as there were thousands of requests for information from the public, averaging 3,500 to 4,500 calls monthly and over 1,000 media inquiries. Challenges occurred because there were other high-profile blooms at the same time, including those in/from Lake Okeechobee. There was also skepticism on social media and news outlets. To mitigate these challenges, FWC used existing communication tools and adapted them to meet the demands of this event. This included increasing the number of information calls, conducting weekly calls with experts and emergency response management teams, and regularly calling stakeholders to keep them informed. FWC developed and frequently updated publicly available mapping tools to keep the public and response community informed. Hubbard summarized communication solutions

as: 1) share what you do know and update as you know more, 2) share what you do not know, and 3) describe next steps.

Hubbard concluded by recognizing the different partners that were involved in responding to this event. Each partner was responsible for different elements of the response. It is important to establish relationships among partners prior to events occurring.

C. Plenary Presentations Day 2

Overview of Risk and Crisis Communication

Katie Krushinski, NOAA defined terms commonly used in risk and crisis communication. Risk is the threat of loss, real or perceived, of that which we value. Risk is determined by the hazard multiplied by the consequence. Krushinski reviewed three common definitions of disasters in emergency management. Each definition explains that disasters are destructive, disruptive, and can overwhelm community resources. A crisis is a specific unexpected and non-routine event or series of events that creates high levels of uncertainty and threatens an organization's high priority goals. Emergencies, disasters, and catastrophes are often used interchangeably, but differ regarding their impacts, geographic extent, pre-incident planning, response resources, public involvement, and recovery. For example, the public is not generally involved in response during an emergency. However, during disasters, the public is extensively involved in response. During catastrophes, the public is extensively involved in response and long-term recovery efforts.

Risk communication is a science-based approach for communicating effectively in a high concern environment that includes low trust, a sensitive topic, or a controversial situation. It is focused on what might happen (e.g., an approaching hurricane) and is the exchange of information about the nature of the risk and risk management options.

There are three goals for risk communication: 1) increase knowledge and understanding by providing clear, concise, and science-based information, 2) enhance trust with the audience, and 3) resolve conflicts quickly as they occur.

Crisis communication is the exchange of risk-relevant and safety information during or after an emergency. It is focused on what has already happened (e.g., a hurricane has hit). Crisis communication is message driven, using the rapid response communications from external/public affairs staff.

An individual's perception of risk can be influenced by experiences, socioeconomic factors, and the availability of information. People often compare disasters and their impacts to experiences they previously encountered, sometimes making it seem like a lesser risk. Socioeconomic factors include, but are not limited to, employment, education, and income. They influence people's perception of risk from a hazard. It is important to understand the different populations that comprise the intended audience when delivering messages.

There are four ways to build and maintain trust within an audience: 1) empathy, 2) honesty, 3) dedication, and 4) expertise. To build trust, a communicator needs to: acknowledge uncertainty, errors, deficiencies, and misbehaviors; establish their own humanity; apologize early and often if

mistakes are made; and avoid comparisons. To inform the public, it is important to: prepare at least three times the number of facts and figures that are needed; stay organized; dress appropriately; be concise, clear, and brief; develop key messages specific to stakeholders; and actively listen.

Krushinski emphasized that it is essential to communicate through social media. An organization should dedicate a staff member to post and handle rumor control during the event. The social media platforms used to share information should be based on the target audience and focus on sharing science-based information.

Non-verbal actions provide more than half of message content when communicating. Audience members notice non-verbal cues immediately and can interpret them negatively. Non-verbal communication overrides verbal communication (e.g., Flint Michigan water crisis press conference where a speaker was drinking from a plastic water bottle). Krushinski concluded by stating the importance of knowing the audience, making a well written risk and crisis communication plan, and communicating early and often.

Communication Panel Discussion

Lesley D'Anglada, USEPA gave an overview of the agency's risk communication tools to use before, during, and after a cyanoHABs and cyanotoxin event in drinking and recreational waters. USEPA's risk communication includes three key components: 1) preparedness, 2) response, and 3) post-incident assessment. The contact information from the agencies that will assist in the response should be developed ahead of an event. Additionally, a Cyanotoxin Management Plan should be developed to include the steps to manage the HAB event and communicate risks with the public. USEPA has many risk communications tools to aid in HAB preparedness including: USEPA's Cyanotoxin Management Plan Template and Example Plans, Drinking Water Cyanotoxin Communication Toolbox, Recreational Water Cyanotoxin Risk Toolbox for Cyanobacterial Blooms, and USEPA HABs Incident Action Checklists.

D'Anglada described USEPA's response resources to assist during a HAB event. These resources include the Harmful Algal Blooms and Cyanotoxins Frequently Asked Questions, Frequently Asked Questions: Laboratory Analysis for Microcystins in Drinking Water, Monitoring and Responding to Cyanobacteria and Cyanotoxins in Recreational Water, Recommendations for Public Water Systems to Manage Cyanotoxins in Drinking Water, and Water Treatment Optimization for Cyanotoxins, among others. These resources enable quick communication with the public and media, are easily accessible and ready to use.

After an event, D'Anglada recommends conducting a post-incident comprehensive assessment to assess the adequacy and effectiveness of the cyanotoxins incident response. In addition, agencies should conduct a final debrief with all parties involved in the response to identify problems during the incident and determine areas for improvement. USEPA developed the Incident Action Checklist-Harmful Algal Blooms for doing this. The agency is releasing two additional tools: a cyanotoxins preparedness and response toolkit, and an implementation document for recommended cyanotoxin water quality criteria.

Jonathan Lynch, CDC discussed his background, experience, and the importance of building partnerships. It is important to establish communication channels ahead of time with local communities that may be impacted by HAB events. One way to do this is the social platform nextdoor. Agency representatives can post on this platform and local community members can share it within their neighborhoods. Lynch concluded by reiterating that partnerships and communication channels should be set up before an event occurs.

Stacey Wiggins, FDA discussed the agency, and its partners, communication resources focused on molluscan shellfish. Wiggins highlighted the FDA seafood webpage where many safety resources are located. Resources on this webpage include a link to the ISSC webpage and FDA's Bad Bug Book which includes a chapter on HAB toxins that may impact shellfish.

Wiggins explained additional communication resources on the ISSC webpage. Notifications related to shellfish are posted on this website, including illnesses/outbreaks, shellfish closures, reopening, and recalls. There is also a section which includes a list of domestic laboratories that conform to NSSP requirements for performing biotoxin analysis. The webpage also includes a link to the ISSC Constitution, Bylaws and Procedures as well as the NSSP Guide for the Control of Molluscan Shellfish which outlines safety requirements. The NSSP Guide includes information on marine biotoxin control and allowable laboratory methods.

Andrew Reich, Consultant discussed some of the challenges the Florida Department of Health face regarding HAB events. Communities in Florida include residents and tourists who are often multilingual; English being their second language. It is important to know your audience and tailor outreach and education materials. Different communities have cultural preferences, specifically with diets. Some communities harvest and consume non-commercial and unregulated aquatic species that may not be monitored. There are economic disincentives to following HAB guidance became Florida's economy centers on tourism. Additionally, tourists in the area are not likely to watch local news and therefore it can be hard to communicate with them during an event. There can be push-back from communities that do not understand or believe in the science being communicated about an event. Reich concluded by discussing fatigue in communities that frequently experience HAB events. These communities, over time, may become insensitive to outreach material and communication strategies.

Dan Ayres, Washington Department of Fish and Wildlife discussed the challenges and recommended communication strategies to use during HAB events. Ayres discussed the impact HAB events have on Washington's primary commercial (Dungeness crab) and recreational (Pacific razor clams) fisheries. HABs can produce domoic acid that becomes concentrated in shellfish tissue and often causes rapid fishery closures. It is difficult to communicate the sudden closures since recreational harvesters are scattered across Washington and Oregon and commercial crab harvesters are difficult to reach when at sea. Ayres described the tools used to quickly announce closures which include: standard news releases, email distribution lists, no-reply text systems, updated webpage with infographics, and maps of closed areas. Staff members also monitor and update social media accounts.

Ayres highlighted public communication strategies stressing the importance of including under-concerned and overly concerned people in the target audience. He suggested keeping messaging

simple yet compelling and avoiding sudden closures, if possible. When communicating with industry, one should be transparent and notify what is not known about the situation. Additionally, one should avoid using alarmist language, jargon, and streams of facts, and keep the science as simple as possible.

Lacey Goeres-Priest, City of Salem, Oregon discussed the communication strategies the city's Public Works Department used when they experienced cyanotoxins in their finished drinking water supply in 2018. The City of Salem was required to issue two water advisories for vulnerable populations. These advisories informed residents to avoid drinking city water due to the presence of HAB toxins. The advisories lasted for 364 days as the city worked to mitigate the cyanotoxins in the drinking water supply and increase treatment operations in the raw water.

The event was met with significant communication challenges. First, there was a time delay in receiving data from laboratories. Goeres-Priest noted that it was hard to express confidence to the public when the data does not reflect the current situation. Additionally, cyanotoxins and this associated health advisory levels are complicated and technical, making them difficult to communicate. There were also concerns about who was part of the vulnerable population and had to follow the advisory.

Goeres-Priest recommended that utility organizations have their public information officer be an expert in drinking water. All information related to drinking water treatment, testing, and monitoring programs should be easily accessible on a public website. Additionally, it is important to have a dedicated joint information center for all communication and dedicated communication staff. Technical staff are not trained in communication and media relations and therefore should not be the primary spokespersons. Goeres-Priest concluded by emphasizing the importance of using social media to provide updated scientific information to the public.

Is there a bloom?

Rick Stumpf, NOAA discussed the applications of remote sensing for HAB events in marine and freshwater. Remote sensing satellites are designed for land or water. Land sensors generally have higher spatial resolution while water sensors have more frequent imagery. When comparing satellites, there are tradeoffs for spatial, temporal, and spectral resolution. Most satellites deliver quality resolution for only two out of the three categories. When considering resolution for HAB events, the satellite will need enough pixels to ensure that information from the water is being captured. If land is detected, the land signals will interfere with resolution of water data.

Stumpf presented the spectra of light reflectance from the water in a typical coastal and cyanobacterial blooms. Typical blooms tend to absorb blue light (400-500 nm wavelength) due to chlorophyll and reflect green light (500-600 nm wavelength). In a diatom or dinoflagellate bloom, the red wavelength increases. Contrastingly, in a cyanobacteria bloom it decreases. This pattern enables scientists to distinguish between the blooms effectively. It is more difficult to distinguish between diatoms and dinoflagellate blooms since they have similar pigments and wavelength patterns. Stumpf highlighted different applications of remote sensing by using examples of the 2018 Florida red tide event, the wastewater discharge in Pine Point, FL, and the HAB event in Lake Okeechobee.

Using the "optics" from satellite pixels is insufficient to identify all HAB events. Bio-optically-based methods are good for identifying cyanobacteria blooms compared to dinoflagellate and diatom blooms. For dinoflagellate and diatom blooms, ecological data such as temperature, salinity, and geography, is important to collect to help distinguish between them. Biology can also be used to distinguish between different species (e.g., dinoflagellates swim and diatoms do not). Stumpf noted that remote sensing data cannot identify toxins, only intense pigments. If data collected from the field identify toxins, satellite imagery can be used to track the bloom over time. Stumpf concluded by stating that many agencies are continually producing new technology for data collection and provided a list of sources for access to HAB data.

Tyler King, USGS presented on the use of remote sensing to detect HAB events in small inland water bodies. These water bodies are common, experience blooms, and require high spatial resolution imagery. Coarser resolution satellites observe fewer water bodies than satellites with higher spatial resolution. However, having higher spatial resolution imagery comes with tradeoffs. It is important to understand the information that can be extracted from "data sparse, pixel rich" imagery.

King described an example of a water body in Idaho where a bloom appeared to be present. When comparing the spectral features from the bloom water to non-bloom water, elevated green and near-infrared light was observed, consistent with chlorophyll-a. High spatial resolution imagery can map chlorophyll-a, which is a useful precursor to identify HABs. However, the presence of chlorophyll-a does not mean that toxins are present. There are other pigments, such as phycocyanin, which are better indicators of a HAB event and are detectable by other sensors. This is the foundation for mapping cyanobacterial blooms on a coarser scale. King reiterated that remote sensing imagery cannot detect toxins but can detect other components of a potential HAB event.

King described another application of remote sensing in July 2020. The images were processed the same day they were taken and estimated the probability of elevated chlorophyll levels in the water. The next day, field samples were collected from the center of bloom and underwent laboratory testing. Following the laboratory data, a public health notice was issued for anatoxin-a and microcystin. Hence, imagery informed field sampling procedures to save time and money.

There are limitations with remote sensing approach described as it does not differentiate between cyanobacteria and other algae. There are uncertainties about the transferability of this research to other locations. Lastly, many factors can cause interference including clouds, shadows, smoke, sediment, wind, sun glint, bottom reflection, aquatic vegetation, ice, boats, and docks.

Is the bloom producing toxins?

Keith Loftin, USGS discussed different methods that can be deployed to measure cyanotoxins during event response. These methods range from non-target screening methods to targeted analytical methods including: mode of action assays (e.g., enzyme inhibition, receptor binding), Enzyme-Linked Immunosorbent Assays (ELISAs), liquid chromatography, and mass spectrometry. The latter is the best detector for specificity, accuracy, and precision combined. Loftin presented a chart on cyanotoxin method selection which detailed factors to consider relative to analysis time. The analysis time, cost, and cyanotoxin specificity increase with method complexity. There are

currently three commercially available kits for measuring cyanotoxins mode of action: 1) Acetylcholinesterase inhibition – anatoxin-a(s) (unvalidated), 2) Nicotinic Acetylcholine Agonist (anatoxins), and 3) Protein Phosphatase 2A (microcystins, nodularins). There is a need for more mode of action assays to screen for other cyanotoxin classes such as saxitoxins and cylindrospermopsins. ELISAs useful for sample screening are commercially available for anatoxins, cylindrospermopsins, microcystins/nodularins, and saxitoxins. Additionally, many classes of cyanotoxins are under-studied.

The gold standard for cyanotoxin specificity and quantitation has been the triple quadrupole mass spectrometer. However, with recent advancements, high resolution mass spectrometry can also provide quantitative analysis. Loftin described a method used for a range of salinities, (freshwater to ocean) with minimal sample preparation. All analytical methods have limitations, and one needs to consider fitness for purpose, cost, and time requirements. Loftin noted the importance of connecting with laboratories before sampling events to discuss the methods and environmental conditions (e.g., pH, salinity, turbidity) to ensure that samples are collected and preserved properly and to make sure the correct toxins are being measured in an appropriate concentration range.

John Ramsdell, NOAA discussed different tools to measure and quantify marine algal toxins. Algal toxins can be measured by biological, biochemical, and chemical methods. Biological methods include mouse bioassay, cell-based assays, and receptor-based assays. Biochemical methods include ELISA, lateral flow devices, and biosensor methods. Chemical methods include high performance liquid chromatography (HPLC)-ultraviolet (UV) and HPLC-fluorescence detector (FLD), and liquid chromatograph – tandem mass spectrometry (LC-MS-MS).

Marine toxins are dangerous at very low levels and the detection required is ~ 1,000 times lower than most pollutants. It would take about 1.5 mg of saxitoxin to kill an adult as it blocks nerve conduction in the diaphragm and chest wall. This leads to respiratory paralysis, hence the name Paralytic Shellfish Poisoning.

The gold standard method for Paralytic Shellfish Toxins (PST) is the mouse bioassay. The assay measures the time until the last breath the mouse takes following injection. Receptor assays are high throughput and correlate well with the mouse bioassay as an accepted regulatory method worldwide. The receptor for saxitoxin is the sodium ion channel which is responsible to generate nerve impulses.

Ramsdell described three biochemical methods: test strip, ELISA, and sensors. Biochemical assays use antibodies to recognize the presence of a toxin and are commonly used for early detection. Unlike biological assays, biochemical methods do not measure toxins relative to their individual potency. One example of a biochemical method is the second-generation environmental sample processor that uses a printed antibody and DNA array to measure toxins and algae and operates as an autonomous underwater testing laboratory.

Chemical methods work by first separating toxin samples by chromatography, followed by detection of the individual components. Toxins are separated by their known chemical properties using HPLC. To detect by tandem mass spectrometry, fractions that carry the toxin of interest are ionized and identified by a ratio. The mass-to-charge ratio for the toxin of interest is selected and

broken into fragments and the identified fragments are monitored in the samples. This process is performed for each of the toxin forms of interest. This is critical information when there is a need to know the exact toxins during a significant event.

Ramsdell recognizes that although experts on toxin detection exist in several agencies, there is a growing need for a repository of trusted information. Currently, the Intergovernmental Panel on Harmful Algal Blooms (IPHAB) is building an interactive toxins database referencing more than 1,000 algal and cyanotoxins. The database will include chemical information, detection methods, and toxicity. It is designed to integrate with three databases:1) Intergovernmental Oceanographic Commission (IOC)-United Nations Educational, Scientific and Cultural Organization (UNESCO) Taxonomic Reference List of Harmful Micro Algae, 2) World Register of Marine Species (WoRMS), and 3) Harmful Algae Event Database (HAEDAT). During a HAB event, users can have immediate access to accurate information to identify HAB species and past HAB events.

Who and/or what is at risk?

Virginia Roberts, CDC discussed HAB public health efforts with a focus on two CDC surveillance systems. During a HAB event, people and animals are primarily exposed to toxins through skin contact, inhalation, and ingestion of contaminated food or water. Animals may serve as early indicators of a HAB occurrence, might be at an increased risk for exposure or illness, and provide information on the risks and health impacts of HABs.

There are many public health questions about HAB exposures and the illnesses they cause. Roberts explained that the CDC is still evaluating the frequency and geographic distribution of these illnesses to better characterize their clinical presentation and risk factors and inform public health prevention. One way to address these questions is through public health surveillance which is an ongoing process of systematic collection, analysis, and interpretation of outcome-specific data. Data are used in the planning, implementation, and evaluation of public health practices. CDC conducts this work through the One Health approach that recognizes the health of people is connected to the health of animals and our shared environment. It is a collaborative approach that considers the benefits of working together to achieve optimal health outcomes.

Roberts highlighted two CDC surveillance systems that collect HAB-associated illness data: 1) National Outbreak Reporting System (NORS), and 2) One Health Harmful Algal Bloom System (OHHABS). NORS is used for many types of human outbreaks. In NORS, state and territorial health agencies can report aggregate information about two or more ill persons linked to a common exposure (e.g., swimming in a lake). The downloadable NORS dashboard provides public information about water and food born illnesses.

OHHABS launched in 2016, is dedicated to collecting information about HAB events, and human and animal cases of illness. OHHABS does not replace routine water monitoring, real-time investigation tools, or event response systems. The system is nationally available to state and territorial health departments and animal or environmental health partners that may be designated by these health departments. Users of the system classify events using a standard set of definitions based on current scientific understanding; the system be refined over time.

In the first national summary of OHHABS data, published in 2020, there were 18 early adopters that reported a total of 421 HAB events, 389 cases of human illnesses (no deaths), and 413 animal illnesses (369 deaths) for 2016 - 2018. Roberts highlighted some of the key findings from this report including the percentage of illnesses corresponding to large HAB events, age of ill patients, time to illness onset, and the percentage that sought health care. Roberts detailed similar information for animals that became ill from HAB events.

OHHABS data summary represents the launch of national public health surveillance for HAB events and illnesses in the U.S. It can help to better understand the impact of HABs on human and animal health. Many states and territories are still integrating these activities into their HAB programs. A continued One Health approach to surveillance, paired with scientific research findings and increased access to specimen testing, will improve public health.

Elizabeth Hamelin, CDC discussed the public health response to HAB toxin exposures. The focus for clinical sample testing is to determine who was exposed, identify the exposure agent, support emergency response, determine geographical distribution, and potentially track long term health effects. CDC works with state public health laboratories, to collect samples, distribute samples for testing, ensure consistent results between laboratories and evaluate the entire process annually by shipping spiked samples and having laboratories analyze and report results in real-time.

There are many factors to consider when detecting toxin exposure. CDC looks for a specific toxin, and its metabolites or adducts. The metabolism and excretion of each toxin as well as the biomarker selected, will determine how long scientists have to identify the compound for which they are searching (e.g., hours, days, weeks). The sample matrix (e.g., urine, blood, oral or nasal mucosa, hair) will impact the laboratory methods used for analysis. Typically, CDC designs methods to identify toxins at the lowest possible concentrations to confirm low dose exposures. The CDC is continually working to measure additional toxins, detect smaller quantities, improve efficiency, identify new biomarkers, include additional matrices, and enable laboratory transfer for nationwide capabilities.

CDC provides study and response support for human and animal exposure studies testing for microcystins and brevetoxins. The agency may also collect and analyze clinical specimens from a HAB event to confirm suspected exposures. Hamelin concluded by stating that every piece of information collected helps to improve the understanding of toxin exposure and the public health impacts.

Vera Trainer, NOAA discussed two classes of HAB impacts: HAB toxins that harm humans, and these that harm shellfish, but may not harm humans. Typically, the most studied HAB organisms are those that can be toxic to humans when shellfish are eaten. This costs over $100 million per year in public health and management efforts. These events also cause fishery and harvesting closures, lost recreation and tourism opportunities, and additional costs for monitoring and response operations. Toxins that impact shellfish, but do not necessarily harm humans, can cause substantial economic impacts to the fisheries and aquaculture industries.

There are many HAB-related human illnesses that occur when phytoplankton produce toxins that can get concentrated in shellfish tissues. When people, or marine organisms, eat the shellfish

or planktivorous fish (e.g., sardines, anchovies) they can become ill or die. In the Pacific Northwest, domoic acid is one of the primary HAB toxins that can cause amnesic shellfish poisoning in humans. Paralytic shellfish poisoning is caused by human ingestion of seafood contaminated with saxitoxin and related toxins.

In the Pacific Northwest, shellfish mortality events occur in the summer months. There are likely several factors that cause these mortality events, such as temperature and pH. Some of these events are due to toxins that directly kill shellfish, such as yessotoxins. These toxins and their impacts on shellfish are under-studied in the region and are believed to be one of the causes of "summer mortality."

Trainer described the SoundToxins Program which is an early warning system for HABs in Puget Sound, WA. It maps current risk levels for HAB species at different sampling sites. The maps show colored symbols that represent different concentrations of these species. State managers can access this program in real-time to monitor and determine high risk areas. The Washington State Department of Health uses SoundToxins data to minimize risk to shellfish harvest and supplement toxin data. These types of monitoring programs are an essential part of any disaster preparedness plan and should be sustained to help mitigate new HABs appearing due to climate change and other causes.

Trainer also highlighted the Pacific Northwest HAB Bulletin, which is a forecasting tool. This tool integrates data such as toxin and cell monitoring on the coast, offshore boat sampling at hot spots, weather predictions, models on cell transport, and climate change indicators. It helps to facilitate local management decisions. The forecasting programs in the Pacific Northwest, including the PNW HAB Bulletin and the SoundToxins Program, are important tools needed to mitigate the increasing threat of HABs in the region. These programs are the "eyes on the coast" that allow scientists and managers to be informed of HAB threats and initiate timely mitigation and management.

Heather Barron, CROW discussed the impacts of brevetoxicosis on wildlife in Southwest Florida. Sanibel, FL, where CROW is located, is an epicenter for red tides which are an economic and ecological stressor in the region. Additionally, they cause marine wildlife mortality and morbidity events annually.

Barron described a previous study that evaluated three red tide events and found that there was an increase in patients corresponding to an increase in *Karenia brevis* density. In a current study, it appears that wildlife are among the most sensitive to HAB events and brevetoxicosis. Sea turtles, pelicans, gulls and terns, and double creased cormorants are the most affected. These species present a wide variety of clinical signs that vary by species. They are diagnosed with brevetoxicosis by using a competitive ELISA assay. The limit of detection in this assay is 1-2 ng/ml. Plasma values in birds have been observed from 1-16.2 ng/ml and from 1-93.4 ng/ml in sea turtles.

CROW has recently conducted studies response to wildlife impacted by HAB events. A current study focuses on predatory seabirds as sentinels for emerging red tide blooms. Barron concluded by highlighting recent technological advances to improve wildlife survival rates. Initially, birds with brevetoxicosis had 25-30% chance for survival. As technology advanced, the survival rate increased

to 55%. The development of an intravenous lipid emulsion (IVLE) therapy has increased the survival rate to 86% and 94% for birds and sea turtles, respectively.

Barb Kirkpatrick, GCOOS discussed a study on the respiratory impacts of red tide (*Karenia brevis*). The first occupational health exposure study conducted in 2001 – 2002 using healthy lifeguards. A 5-day pre-and post-shift evaluation looked at symptoms and spirometry during a red tide event and a normal (non-red tide) event. There was no change in pulmonary function and the lifeguards only experienced upper airway symptoms.

A similar study evaluated asthmatics over 10 years, with a cohort of people over 12 years old. The results showed that asthma was trigged by HAB toxins after 1-hour of exposure on a beach during a red tide event. Asthmatics experienced 5-days of increased upper and lower airway symptoms in addition to decreased air flow. Common asthma medications should be effective to decrease these symptoms.

Kirkpatrick explained that the measured amount of brevetoxin in the air that can cause symptoms is very small (ng/m^3). Some studies show that these toxins travel at least 1 mile inland. In the U.S., ~ 9% of the population is diagnosed with asthma. Therefore, if a popular beach has 10,000 visitors, 900 of them could get sick for days. This could have significant impacts for public health, tourism, and the economy. HABs and their toxins can be patchy, so there is a need for increased monitoring temporally and spatially as toxic aerosols vary with wind speed/direction.

Kirkpatrick highlighted a new monitoring approach called HABscope which is a microscope with a 3D printed adapter that holds an iPod. Citizen science volunteers use their HABscope unit to take videos, in lieu of counting cells. The videos are sent to GCOOS where an image recognition software identifies the likelihood of the cells being *Karenia brevis* and calculates cell abundance. GCOOS and NOAA-NCCOS have a new HAB forecasting tool that incorporates all the cell counts that state partners and citizen science volunteers collect. This tool is updated every 3 hours and identifies changing beach conditions and their associated risk levels for aerosolized toxins.

Teri Rowles, NOAA described HAB impacts on marine mammals using case studies to demonstrate acute and chronic impacts. Algal blooms are increasing worldwide and may affect marine mammals directly via toxicosis through food webs and aerosols, indirectly through impacts on prey, or secondarily through management decisions.

High levels of saxitoxin, brevetoxin, and domoic acid in prey may cause mortality and/or long term morbidity in marine mammals and in some cases (i.e., domoic acid, transplacental toxicity) lifelong neurological alterations. Many HABs and their toxins have been documented in marine mammals along most of the U.S. coast with low or high level exposures periodically associated with morbidity and mortality events.

There is a long history of marine mammals and HABs. For example, the strandings of 14 humpback whales in Cape Cod Bay, MA from November 1987 to January 1988, was one catalyst for amending the Marine Mammals Protection Act in 1992 to establish the Marine Mammal Health and Stranding Response Program. The goals of this program are to investigate marine mammal unusual mortality events and the impacts of environmental conditions on marine mammal health trends in the wild.

Over the past 35 years, there has been increasing evidence of HAB-associated impacts on marine mammals in many of U.S. marine and estuarine waters including: saxitoxicosis mortality events in U.S. and Canadian waters; brevetoxicosis morbidity and mortality events in manatees and cetaceans in the Gulf of Mexico; domoic acid toxicosis in sea lions and cetaceans along the west coast; and microcystin toxicosis in sea otters off the coast of California.

Survivors of domoic acid toxicosis (i.e., *in utero,* in juveniles/adults) have lifelong impacts that lead to abnormal behavior or seizures. In addition to direct toxicosis, there have been HAB-associated prey depletion and management decisions for fishery activities that have secondarily affected marine mammals. Marine mammals are most often exposed to toxins through the food web, however, there may be physical and temporal distances between the recognized bloom and marine mammal mortality events. Marine mammals may serve as sentinels to trigger additional sampling or observations. Nationwide, lower levels of biotoxins have been found in free swimming marine mammals with no clinical signs or in carcasses that have a known cause of death unrelated to the toxin.

Significant data gaps have been identified that would enhance our understanding of the impacts of HABs on marine mammals. These include the effects of repeated low dose exposure, effects of exposure to multiple toxins at one time, pathophysiology and timing of injury post exposure, and long-term impacts of exposure, including *in utero*, on individuals and populations.

What can be done?

Martin Page, USACE presented USACE's current research project called the Harmful Algal Bloom Interception, Treatment, and Transformation System (HABITATS). HABITATS is an integrative, high throughput process for physical removal of HAB biomass from freshwater bodies and managing that biomass once it is removed. The focus of this research is the integration of three steps for HAB removal: 1) interception, 2) treatment, and 2) transformation. The interceptors are floating weir skimmers that target algae near the surface. Currently, the interception process is primarily designed for surface bloom clean up. The water treatment process includes dissolved air floatation, ozonation, and energy efficient biomass dewatering. The treatment methods work well for clarifying the water, separating the algae, and destroying any dissolved cyanotoxins before returning clean water back to the environment. A hydrothermal liquefaction process has the potential for rapid transformation of the concentrated biomass once it is out of water. The process retention times are ~ 30 minutes, as opposed to bioreactors which might require days to weeks of residence time. HABITATS should be an energy neutral process with no waste streams, metrics which USACE and collaborators aim to achieve at small scale within the next year.

HABITATS can physically remove algae, as well as nutrients and toxins that are contained within the algae. It destroys dissolved and intracellular cyanotoxins in the water and in the removed biomass. The HABITATS component processes have relatively high throughput and have the potential to be energy neutral. Resource recovery can help offset remediation costs and enable scalability.

Over the past two years, USACE has performed four pilot scale field tests to assess the technologies performance and optimize integration. The first hydrothermal liquefaction studies were executed

this year and were successful for. Currently, work is being done to improve concept scalability and impact by optimize the algae dewatering step and performing design and analysis of a larger deployable HABITATS module. The modular onshore system will treat up to 2 million gallons per day, while still being mobile and rapidly deployable. In addition to the onshore system, a shipboard system was built last year to go into a HAB areas as the blooms are forming.

Page concluded by describing the expected impacts and costs of the HABITAT system using a hypothetical case study. For a given array of HABITATS modules, the impact of algal removal from a flowing channel is dependent on the flow rate; but it is also sensitive to the distribution of algae in the water column. For surface blooms, HABITATS would be effective and scalable. However, scalability would be limited when algae are dispersed throughout the water column. For seasonal bloom control, the cost would be considerably lower than if the system were running most of the year. Operational costs were modeled over a 20-year period, which is slightly lower than the projected life cycle of the current systems. The cost projections presume that research on waste stream elimination and efficiency optimization will be successfully completed over the next year of the project. HABITATS is funded through the USACE Aquatic Nuisance Species Research Program.

H. Dail Laughinghouse, University of Florida discussed the chemical management and treatment methods for CyanoHAB events. HAB responders and managers need proactive and reactive tools which can be chemical, physical, mechanical, or biological agents. Proactive chemical methods include nutrient mitigation, water quality enhancers, and dyes. Reactive chemical methods include USEPA-registered algaecides, dyes, flocculants, polymers, and coagulants.

Blue dyes are commonly used as a proactive measure since they are non-toxic, registered for use in lotic systems and control growth by competing with the photosystem II pigment. Another proactive chemical management product is lanthanum-modified bentonite clay (known as Phoslock). This phosphorus controlling method can absorb microcystins and sediment them out of the water. There are 11 USEPA-registered algaecides that are used in reactive chemical management. The most used are peroxides and copper algaecides. The registered peroxides are sodium carbonate peroxyhydrate and hydrogen peroxide and peroxyacetic acid. Peroxide algaecides work by oxidizing algae and other organic components into oxygen and water. These algaecides can be selective to some cyanobacteria and are more effective in high light intensities.

The copper algaecides are copper sulfate, copper ethanolamine complex, and copper citrate and copper gluconate. Copper works by: disrupting electron transport; preventing cell division; interfering with cell permeability and binding essential elements; penetrating mucilage, colonies, filaments, mats, and cell walls; and inhibiting enzyme catalase, photosynthesis, phosphorus uptake, and nitrogen fixation. Laughinghouse noted the importance of understanding specific water conditions such as pH, alkalinity, temperature, and hardness. All these variables affect the efficacy of copper.

Laughinghouse concluded by reiterating the need for more science-driven data on current and new treatment methods. More studies are also needed to assess the feasibility for different systems, including scale up potential and cost. Efficacy for different HAB chemical treatments will vary for different cyanobacteria and water conditions. Additionally, there is a need for long term data on the effects of chemical response methods on environment and non-target organisms.

VI. Tabletop Exercise

The virtual tabletop exercise occurred on April 29, 2021. Exercise participants were divided into five breakout groups with local, state, and federal decision-makers in each group. The hypothetical scenario was a hurricane that caused a HAB event when freshwater input predominated Galveston Bay, TX (Module 1), which then migrated to marine waters in the Gulf of Mexico (Module 2). Each group was tasked with discussing the two modules and answering a series of questions related to the response. The Situation Manual is located in **Appendix C**. An After-Action Report with detailed descriptions of the tabletop exercise outcomes and subsequent action items is located in **Appendix D**. A list of the tabletop exercise participants is in **Appendix E**.

A. Freshwater HAB Response

The first breakout group session focused on the freshwater cyanobacterial bloom response. Participants discussed the following questions:

1. Which agency(ies) should be communicating/coordinating to respond to the cyanobacterial bloom in Galveston Bay? Which agencies should respond to the dog death?
2. Does your agency have a process/plan/procedure in place to respond to a cyanoHAB event in freshwater water bodies? If yes, what does the process/plan/procedure cover/address?
3. What agencies provide science-based information related to the cyanoHAB event in a freshwater environment that could be used to help decision-makers? What type of information is provided?

Following the session, one member from each group summarized the discussions during a plenary report-out. Detailed notes from each group are located in **Appendix F**.

All groups agreed that state agencies have the primary responsibility to respond to the HAB event (exception would be if it occurred in Federal waters); Federal agencies (e.g., NOAA, USEPA, USGS, CDC, and FDA) would operate in a support role and provide resources at the request of the state. NOAA may provide emergency funding and general event support and has remote sensing/satellite imagery capabilities to track and monitor the bloom. USEPA has freshwater HAB expertise and can assist in sample collection and processing. It may also coordinate with state public health and environmental agencies to determine if drinking water is impacted. USGS has Science Centers in every state that are each capable of assisting in HAB events by providing sampling support. CDC has many publicly available resources (e.g., HAB toolkit) and may assist on HAB-induced public health issues. FDA may provide guidance related to shellfish consumption and shellfish growing area closures. FDA also has laboratory capacity to assist with certain sample processing and analysis. FEMA may be involved in broader emergency management, focused on the hurricane impacts.

For this scenario, a group identified the Texas Department of Health as being the agency that would respond to the any associated pet deaths through the office of the state veterinarian. USEPA and CDC could also be involved.

It was noted that the specific response actions for this scenario are unclear since it is an estuarine system. Groups pointed out that there is a need for formal documentation of roles, responsibilities, and procedures in this type of scenario. Existing state policies, plans, and procedures for HAB event

response vary state to state. For example, in Louisiana, there are no specific protocols that reflect this type of HAB scenario. In Texas, which is a 'home rule' state, all response decision-making occurs at the local level. Overall, each group highlighted the importance of having pre-established networks and relationships prior to the response.

B. Marine HAB Response

The second breakout group session focused on a marine HAB response. Participants discussed the following questions for the Gulf of Mexico:

1. Which agency(ies) should be communicating/coordinating to respond to the cyanobacterial bloom in the Gulf of Mexico?
2. Does your agency have a process/plan/procedure in place to respond to a cyanoHAB event in the marine environment? If yes, what does the process/plan/procedure cover/address?
3. What agencies provide science-based information related to the cyanoHAB event in a marine environment that could be used to help decision-makers? What type of information is provided?

Following the session, one member from each group summarized the discussions during a plenary report-out. For detailed notes from each group are located in **Appendix F**.

The groups noted that the overall response and operational procedures would not change from the Galveston Bay (freshwater) response. State agencies would lead on communicating and responding to the HAB event in the Gulf of Mexico. However, there are not many formal, documented plans for state agencies. Furthermore, some states do not notify neighboring states when a HAB event occurs.

In contrast, there are numerous response and operational guidance documents for a marine HAB events from Federal agencies. Federal agencies, specifically FDA, NOAA, and in a limited role USEPA, would provide assistance and play a more active role in this scenario since the bloom expanded federal waters. They would expand their offered resources by launching cruises of opportunity, enlisting more personnel, and expanding remote sensing capabilities. Federal agencies could also help with response efforts by data collection and analysis, mitigating wildlife impacts, providing real-time data, and helping to coordinate response efforts. Other agencies (e.g., USCG, Florida Fish and Wildlife, and Louisiana Department of Wildlife and Fisheries) have vessels and could help with sample collection.

Each group reiterated the importance of coordinated response efforts, especially between states, for this multi-state scenario. It is also important that Federal agencies coordinate with each other and state agencies. For example, in Texas, there is a network of organizations with expertise in HABs (e.g., academics, technical experts), but there is not one person who assists in state and federal coordination. In Texas, the NOAA HAB event response program facilitates the coordination between different agencies.

Some groups discussed additional challenges that would arise if vessels washed up on shore or sunk during the hurricane. Removing marine debris during a HAB event could transport the cyanobacteria to new regions and stimulate more intense blooms by mixing the water. Another on-going challenge is the location of laboratories relative to sample locations. One group identified the

need to have regionally-located laboratories since all states are collecting time-sensitive water samples.

VII. Workshop Outcomes and Recommendations

The outcomes listed below are actionable items, and commonalities identified during the workshop and tabletop exercise. The outcomes and subsequent recommendations focus on improving the Federal HAB preparedness and response capabilities and support more effective engagement with states.

1. There is a **lack of communication before, during and after a HABs event among Federal agencies and impacted states**. There is uncertainty related to the resources, expertise, capabilities, and responsibilities of Federal agencies to assist states during HAB events. It is important to establish and maintain relationships with partnering states to have an effective, coordinated HAB response.
   The following actions were recommended to address this knowledge gap and increase coordination efforts:
   a. Determine the points of contact (POCs) in each state responsible for HAB event preparedness and response and create a document (e.g., one pager) with this information and the POCs' responsibilities.
   b. Develop and share lists of Federal and state POCs for HAB events.
   c. Facilitate regional groups to encourage relationships between agencies and states prior to a HAB event response.
2. There is **no established process to recruit the assistance of non-mandated Federal agencies**. One potential limitation during HAB responses is the lack of Federal agencies mandated to provide resources in HAB event response. Their participation would require an individual state or other Federal agencies' request for assistance.
   a. Continue discussions on different aspects of HAB response to assess the need for additional mandates to support response efforts.
   b. Develop a template that outlines the state's process to obtain Federal agency support during a HAB event.
3. There were many **gaps identified related to existing plans, policies and procedures used to effectively manage a Federal cross-agency, coordinated HAB response**. Current policies and plans focus on one aspect of the response effort.
   a. Create a database with existing local, state, and Federal HAB event response plans, policies, and procedures.
   b. Evaluate the feasibility of a coordinated, cross-agency guidance document for HAB events.
   c. Organize a cross-agency, regional coordinating body to develop state level plans, policies, and guidelines to increase coordination and consistency during HAB events.
   d. Determine the utility of a HAB response plan template that would allow states to tailor it to their specific preparedness and response capabilities.
   e. Determine the feasibility to pull together state POCs to effectively share information, ideas, and progression of each state's HAB plans and procedures.
   f. Develop regional, easily accessible, information centers to share state and local plans, policies, and procedures.

4. There were additional gaps identified for the **lack of communication between Federal, state, and local agencies and the public during a HABs event.** During the exercise, there was no mention of a formal process for scientific agencies to share information during a HAB event. There was also no standard process for sharing information during a HAB event. These factors contribute to the uncertainty of how to share and communicate critical information to stakeholders and the public.
    a. Create a cross-agency committee to ensure scientific information is effectively shared with stakeholders.
    b. Determine communication-related POCs for cyanoHAB events and create a coordinating body to ensure consistent messaging with the public.
    c. Determine the applicability of creating a cross-agency communications team to create a template for sharing information with the public.
    d. Determine the best channels for communicating and socializing the HAB response process with states and stakeholders (e.g., agencies involved, thresholds to recruit assistance, funding streams, any permit/application processes).

VIII. Next Steps

Based on the workshop and tabletop exercise outcomes, the IWG-HABHRCA has prioritized the following recommendations to advance HAB preparedness and response within the IWG-HABHRCA member agencies and its partners.

1. The IWG-HABHRCA executive secretary will develop and maintain a web-based repository with contact information for Federal HAB responders.
2. The IWG-HABHRCA recommends that its member agencies hold follow-up bilateral conversations with federal (and state) counterparts who have similarly-lined HAB response functions and capabilities.
3. Workshop participants and the IWG-HABHRCA recommend developing additional materials (e.g., one-pagers, short papers) about HAB toxin detection approaches in freshwater and marine environments, including agencies' resources and capabilities for detecting toxins.
4. Workshop organizers and the IWG-HABHRCA will plan to hold follow-up workshops on HAB response. Potential future workshop topics could include addressing Federal, state, and county-level coordinated engagements during HAB response, and coordinated approaches and responses to Great Lakes HAB events.

IX. Appendices

A. Workshop Agenda

B. Workshop Presentations

C. Situation Manual

D. After-Action Report

E. Tabletop Exercise Participants

F. Tabletop Exercise Breakout Group Notes

APPENDIX A
Workshop Agenda

Harmful Algal Bloom (HAB) Preparedness & Response Workshop

April 27 - 28, 2021
1:00 – 4:00 PM (EDT)

AGENDA

April 27, 2021 (Day 1)

1:00 Opening, Overview and Logistics
- *Nancy Kinner, Coastal Response Research Center, University of New Hampshire*

1:05 Overview of Federal Response to HABs
- *Dave Kidwell, IWG Co-Chair*

1:15 Federal Agency Presentations
- *Deborah Nagle, EPA*
- *Kaytee Boyd, NOAA*
- *Fred Tyson, NIEHS*
- *Mike Higgins, USFWS*
- *Danielle Buttke, NPS*
- *Jennifer Graham, USGS*
- *Tony Clyde, USACE*
- *Renee Funk, CDC*
- *Stacey Wiggins, FDA*

2:30 ***BREAK***

2:40 FEMA and ASPR Presentations
- *Joselito Ignacio, FEMA*
- *Leremy Colf, ASPR*

3:05 Compare and Contrast the 2016 Lake Okeechobee Response to Current HAB Responses
- *David Whiting, FL DEP*

3:20 2018 Florida Red Tide Case Study: Scientific and Communication Response
- *Kate Hubbard, FWC*

3:45 Wrap Up
- *Katie Krushinski, NOAA DPP*
- *Dave Kidwell, IWG Co-Chair*

4:00 ***ADJOURN***

April 28, 2021 (Day 2)

1:00 Opening, Overview and Logistics
- *Nancy Kinner, Coastal Response Research Center, University of New Hampshire*

1:05 Overview of Risk + Crisis Communication
- *Katie Krushinski, NOAA*

1:35 Communication Panel Discussion (Q&A Session Included)
- *Lesley D'Anglada, EPA*
- *Jonathan Lynch, CDC*
- *Stacey Wiggins, FDA*
- *Andy Reich, Consultant*
- *Dan Ayres, WA Fish and Wildlife*
- *Lacey Goeres, City of Salem, OR*

2:10 Is there a bloom?
- Early Detection Tools and Remote Sensing, *Rick Stumpf, NOAA*
- Early Detection Tools and Remote Sensing, *Tyler King, USGS*

2:30 Is the bloom producing toxins?
- Tools for Measurement Quantification, *Keith Loftin, USGS*
- Tools for Measurement Quantification, *John Ramsdell, NOAA*

2:50 ***BREAK***

3:00 Who and/or what is at risk?
- Disease Surveillance, *Virginia Roberts, CDC*
- Public Health Response, *Beth Hamelin, CDC*
- Marine Toxins Impacting Fish and Shellfish Health & Harvest, *Vera Trainer, NOAA*
- Wildlife Impacts, *Heather Barron, CROW*
- Red Tide Respiratory Impacts, *Barb Kirkpatrick, GCOOS*
- Marine Mammal Impacts, *Teri Rowles, NOAA*

3:55 What can be done?
- Mitigation Tools, *Martin Page, USACE*
- Mitigation Tools, *H.Dail Laughinghouse, University of Florida*

4:15 Wrap Up
- *Charles Grisafi, NOAA DPP*
- *Tony Marshak, IWG Representative*

4:30 ***ADJOURN***

Virtual Posters: Available for viewing at https://crrc.unh.edu/workshop/HAB
- *Kaytee Boyd, NOAA*
- *Molly Reif, USACE*
- *Mary Kate Rogener, NOAA*

APPENDIX B
Workshop Presentations

Harmful Algal Bloom Preparedness & Response

Nancy E. Kinner, Facilitator
Coastal Response Research Center (CRRC)
University of New Hampshire

April 27, 2021

HOW TO PARTICIPATE

- Software will be Zoom (federal employees do not have to download the client, access through browser)
- Submit questions or comments via the Q&A option
  - Questions will be monitored and collated
  - Facilitator will announce questions
  - Some answers may be available via the Q&A option
- If you have any access issues, please contact Kathy at kathy.mandsager@unh.edu or cell 603.498.8010

COASTAL RESPONSE RESEARCH CENTER (CRRC)

- Partnership between NOAA's Office of Response and Restoration and the University of New Hampshire
- Since 2004
  - UNH Co-Director – Nancy Kinner
  - NOAA Co-Director – Troy Baker

Coastal Response Research Center (NOAA $)

Center for Spills and Environmental Hazards (All Other $)

- Conduct and Oversee Basic and Applied Research and Outreach on Spill and Other Environmental Disaster Response and Restoration
- Transform Research Results into Practice
- Serve as Hub for Spill and Environmental Disaster R&D
- Facilitate Interaction Among Spill/Environmental Disaster Community (All Stakeholders)
- Educate/Train Students Who will Pursue Careers in Spill Response and Restoration

Coastal Response Research Center

HAB PREPAREDNESS & RESPONSE: WORKSHOP GOAL

To better understand:

1. The roles and responsibilities of different Federal HAB response agencies
2. The science and tools that help drive decision-making
3. The importance of inter-agency coordination

HAB PREPAREDNESS & RESPONSE: OVERVIEW

STEERING COMMITTEE

Charles Grisafi, NOAA
Katie Krushinski, NOAA
Tony Marshak, NOAA
Jennifer Graham, USGS
Lesley D'Anglada, USEPA
Tesfaye Bayleygen, CDC
Tony Clyde, USACE
Tony Hill, USACE
Charlie Henry, NOAA
Christine Tomlinson, USEPA
Lorraine Backer, CDC
Stacey Wiggins, FDA
Joselito Ignacio, FEMA
Mary Kate Rogener, NOAA
Nancy Kinner, CRRC
Katie Perry, CRRC

POSTER PRESENTATIONS

Step 1: Go to website (https://crrc.unh.edu/workshop/HAB)
Step 2: Scroll to "Poster Presentation" section
Step 3: Click on the poster links

Agenda: here>>

Poster Presentation

Title: *Harmful Algal Bloom indicator estimation in small inland waterbodies: Remote sensing-based software tools to assist with USACE water quality monitoring*

Authors: Molly Reif (molly.k.reif@usace.army.mil), Richard Johansen, Christina Saltus, and Erich Emery
Affiliation: U.S. Army Corps of Engineers

Title: *NCCOS Harmful Algal Bloom Forecasting Capabilities: Research to Operations*

Authors: Kaytee Pokrzywinski Boyd (kaytee.boyd@noaa.gov) and Timothy Wynne
Affiliation: National Centers for Coastal Ocean Science, NOAA

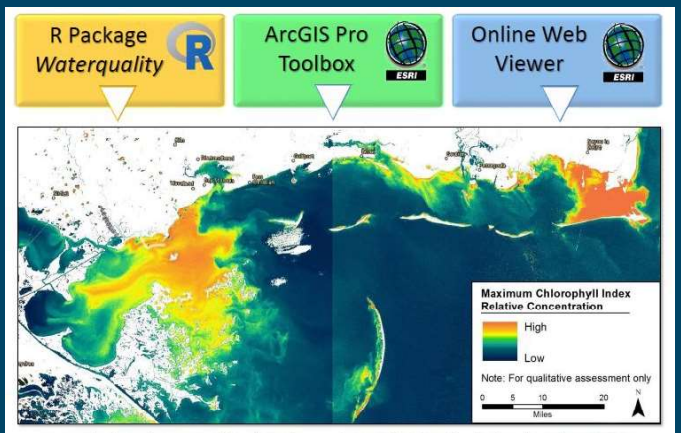
Title: NCCOS Harmful Algal Bloom Event Response Program

Authors: Mary Kate Rogener (marykate.rogener@noaa.gov)
Affiliation: NOOA National Centers for Coastal Ocean Science

Coastal Response Research Center

POSTER PRESENTATIONS

Harmful Algal Bloom indicator estimation in small inland waterbodies: Remote sensing-based software tools to assist with USACE water quality monitoring



Synoptic view of water quality along the northern Gulf of Mexico during the July 2019 HAB outbreak based on two scenes of Sentinel-2 imagery (20-meter spatial resolution)

Authors: Molly Reif, Richard Johansen, Christina Saltus, and Erich Emery

U.S. Army Corps of Engineers

POSTER PRESENTATIONS

NCCOS Harmful Algal Bloom Forecasting Capabilities: Research to Operations

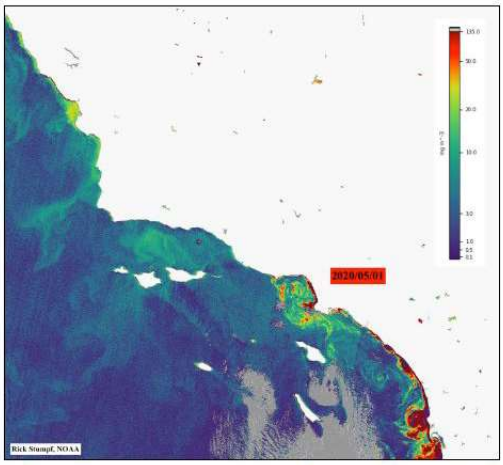
Authors: Kaytee Pokrzywinski Boyd, Timothy Wynne

National Centers for Coastal Ocean Science, NOAA

Coastal Response Research Center

POSTER PRESENTATIONS

NCCOS Harmful Algal Bloom Event Response Program



Satellite Image of chlorophyll concentration showing the extent of a bloom off the coast of Southern California, May 2020. Credit NOAA

Authors: Mary Kate Rogener

NOAA National Centers for Costal Ocean Science

HOW TO PARTICIPATE

- **Submit questions or comments via the Q&A option**
  - **Questions will be monitored and collated**
  - **Facilitator will announce questions**
  - **Some answers may be available via the Q&A option**
- **If you have any access issues, please contact Kathy at kathy.mandsager@unh.edu or cell 603.498.8010**

THANK YOU FOR LISTENING

https://crrc.unh.edu/workshop/HAB

Coastal Response Research Center

Federal Harmful Algal Bloom Response

David Kidwell, Acting Co-Chair
The Interagency Workgroup on the Harmful Algal Bloom and Hypoxia Research & Control Act (IWG-HABHRCA)

National Centers for Coastal Ocean Science (NCCOS)
U.S. Department of Commerce, NOAA

HABHRCA

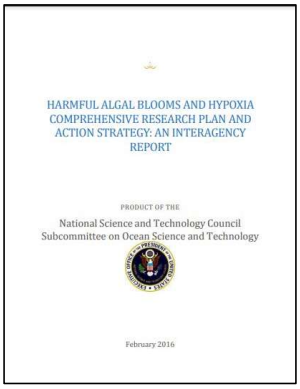
- HABHRCA (1998, authorized) – mandate to describe near and long-term comprehensive efforts to prevent, reduce, and control **Harmful Algal Blooms (HABs) and Hypoxia** in the United States.
  - NOAA has the primary responsibility for administering HABHRCA.
  - Established the "**Interagency Task Force**".

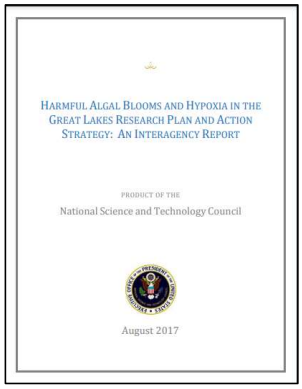
- Reauthorizations:
  - 2004 - expands NOAA's mandate to coordinate and develop **assessments and reports** on HABs and Hypoxia in the U.S.
  - 2014 - includes **freshwater HABs** and hypoxia and **EPA** the responsibility to research, forecast and monitor event response to freshwater HABs.
    - Establishes an **Interagency Working Group (IWG)** composed of NOAA, EPA, and other federal agencies.
  - 2019 - includes **HAB and Hypoxia Events of National Significance** (HHENS).

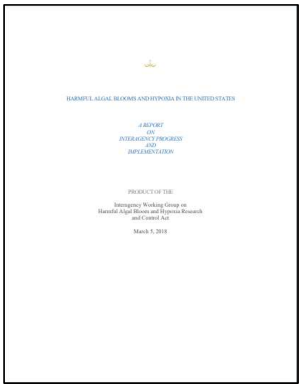
IWG –HABHRCA

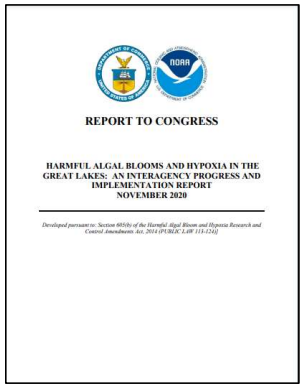
- Co-chaired by NOAA, EPA and SOST.
- Congressionally mandated to respond to legislative requirements of HABHRCA.
- Tasked with coordinating and convening Federal agencies and their stakeholders to discuss HAB and hypoxia events in the U.S., and to develop action plans, assessments, and progress reports of these situations.

IWG-HABHRCA Coordinated Efforts





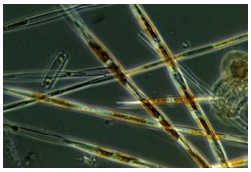


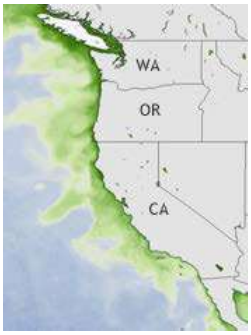


- The IWG-HABHRCA published and transmitted to Congress:
  - *Harmful Algal Blooms and Hypoxia Comprehensive Research Plan and Action Strategy* (2016)
  - *Harmful Algal Blooms and Hypoxia in the Great Lakes Research Plan and Action Strategy* (2017)
  - *Harmful Algal Blooms and Hypoxia in the United States: A Report on Interagency Progress and Implementation* (2018)
  - *Harmful Algal Blooms And Hypoxia In The Great Lakes: An Interagency Progress And Implementation Report* (2020)

Event Response Collaborations

- Federal event response requires considerable interagency collaboration.
- Since late spring 2015, the west coast has experienced an ongoing *Pseudo-nitzschia* bloom.
  - EPA, NOAA, and FDA have worked together to monitor/analyze the bloom, and provide response assistance to local and regional communities.
- Many agencies collaborate to forecast and establish early warning systems for HABs in Lake Erie.
  - In 2015, USGS, NASA, EPA, and NOAA worked together to track the development of a bloom in Lake Erie using satellite and water quality information.
  - Efforts later led to development of the Cyanobacteria Assessment Network (CyAN) program.



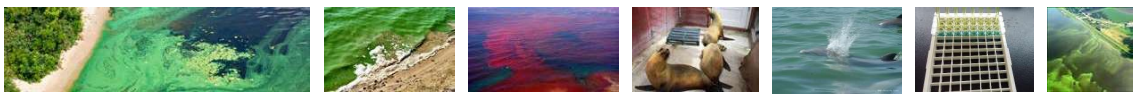


Event Response – Example Agency Efforts

- **CDC** - funds multiple states to develop programs to respond to HAB-related public health issues.
- **FDA** - assists states with sample collection and analysis when marine biotoxins are suspected in state waters, and is the primary responder to blooms in Federal waters when pertaining to food safety.
- **NOAA**
  - **HAB Event Response Program (HABHRCA mandated)** - provides funding for state managers and researchers investigating HAB events.
  - **Marine Mammal Health & Stranding Response Program** and the **Working Group on Unusual Marine Mammal Mortality Events (NOAA, FWS, MMC, EPA)** - Investigate mortality events.
  - **Analytical Response Team** - provides formal framework for coastal managers to request immediate coordinated assistance during HABs with species identification and toxin analysis.
  - **HAB Forecasting & Monitoring** – Efforts in coastal and Great Lakes regions, including W Lake Erie, Gulf of Mexico, Pacific coast, Gulf of Maine, etc.

Event Response – Example Agency Efforts

- **NPS**
  - HAB response reporting website for park managers; events database.
- **USACE**
  - Response programs developed by individual USACE Divisions/Districts. Close coordination with State water quality/public health agencies.
  - ERDC supports assessing HAB impacts to Civil Works Projects.
  - General water quality monitoring and HAB response to meet authorized project purposes and recreation mission requirements.
- **USGS (National Wildlife Health Center)**
  - Mandated for HAB response - provides sample handling and project coordination for investigating wildlife disease or mortality events (incl. HABs).



Agencies' Rapid Response Efforts

- Researchers are establishing rapid sample collections and response protocols for detecting HAB toxins.
  - **FDA**-developed rapid assessment methods to detect HAB toxins in seafood.
  - **NOAA** prioritizes development of rapid-response test kits that stakeholders can use to determine the presence of HAB species/toxins in local waterways.
  - **Water Research Institutes** established in several states to develop new tools to better understand/predict cyanobacterial HABs.
  - **EPA** developed the **Drinking Water Cyanotoxin Risk Communication Toolbox** to support public water systems in communicating information to their consumers before, during, and after a bloom event.
  - **NSF** and **NIEHS** rapid response funding programs.

Interagency Efforts to Enhance HAB Response

- Advancing agencies' abilities to respond to HABs
  - Agencies increasing availability of analytical methods and reference materials
  - **EPA** studies on toxin mixtures and toxins in food
  - **NOAA** assessments of HAB control techniques (algicides, nanobubbles), nutrient loading effects, HAB forecasting efforts
  - **CDC** – reporting One Health HAB System (OHHABS) reporting tool on HAB exposures and subsequent health effects.
  - Improving socioeconomic understanding (and stakeholder engagement)

- Strengthening Long-term HAB monitoring activities
  - **NOAA** Phytoplankton Monitoring Network; National HAB Observing Network (NHABON)
  - **USGS** long-term nutrient monitoring via National Water Quality Network
  - **USDA** Conservation Effects Assessment Project
  - **EPA** National Aquatic Resource Surveys for cyanobacteria/cyanotoxins
  - **USACE/EPA** airborne/satellite imagery for monitoring small lakes/reservoirs

Federal Efforts – Ongoing/Future Directions

- Ongoing Priorities:
  - Additional rapid response strategies for assessing HAB exposure
  - Establish strategies for prevention, suppression, control of HABs.
  - Understanding the influence of climate change, nutrients, and other factors on occurrence, frequency, severity of HABs.
  - Evaluation of socioeconomic impacts of HABs and costs of mitigation.
  - National datasets on human exposure and cyanobacterial monitoring.
  - Continued and improved conservation, implementation, and agricultural management practices to reduce nutrients and sediment losses from agricultural lands.

- IWG Coordinated Planning Document, including priorities and coordination strategies for event response.

For More Information

IWG-HABHRCA Contact Email

IWG-HABHRCA@noaa.gov

NOAA HABHRCA Website

https://coastalscience.noaa.gov/research/stressor-impacts-mitigation/habhrca/

EPA's HABHRCA Website

https://www.epa.gov/cyanohabs/harmful-algal-bloom-and-hypoxia-research-and-control-amendments-act-habhrca

Overview of EPA's Role in Managing HABs in Freshwater Systems

Deborah G. Nagle, Director
Office of Science and Technology, Office of Water
US Environmental Protection Agency

Harmful Algal Blooms Preparedness and Response Workshop
April 27th, 2021

EPA's Mission

Protect Human Health and the Environment

- All Americans are protected from significant risks to human health and the environment where they live, learn and work;
- Reduce environmental risk based on the best available scientific information;
- Enforced federal laws fairly and effectively;
- Environmental protection is considered in all U.S. environmental policies;
- All parts of society have access to accurate information sufficient to effectively participate in managing human health and environmental risks.

Federal Laws that Protects the United State's Waters from HABs

The **Safe Drinking Water Act** (SDWA) protects public drinking water supplies throughout the nation.

The **Clean Water Act** (CWA) establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters.

The **Harmful Algal Bloom, Hypoxia Research and Control Act** (HABHRCA) describes near and long-term comprehensive efforts to prevent, reduce, and control HABs and hypoxia in the United States. .

EPA's Approach to Address HABs

EPA has jurisdiction over **freshwater** HABs and Hypoxia events.

Collaborative effort among:

- Office of Water
- Office of Research and Development
- Gulf of Mexico Program Office
- Great Lakes National Program Office
- EPA Regions
- States, tribes and other federal agencies

Guidelines and Recommendations

- Algal Toxin Risk Assessment and Management Strategic Plan for Drinking Water
- Drinking Water Health Advisories for Microcystins and Cylindrospermopsin
- Recommended Human Health Recreational Ambient Water Quality Criteria/Swimming Advisories for Microcystins and Cylindrospermopsin
- Recommendations for Public Water Systems to Manage Cyanotoxins in Drinking Water

In Progress:

- HABs and Hypoxia Events of National Significance in Freshwater Systems Policy
- Technical Support Document: Implementing the 2019 National Clean Water Act Section 304(a) Recommended Human Health Recreational Ambient Water Quality Criteria or Swimming Advisories for Microcystins and Cylindrospermopsin

Technical Support

- Funding in the Great Lakes, Gulf of Mexico, and many national estuaries.

- Providing satellite-derived water quality information to assist States and tribes forecast cyanobacterial HABs, and support drinking water systems and communities on treatment, monitoring, risk communication strategies, and direct monitoring and laboratory analysis support during drinking water emergencies caused by HABs.

- Technical Support and Supplemental Documents
  - Cyanotoxin Management Plan Template and Example Plans
  - Water Treatment Optimization for Cyanotoxins Document
  - Drinking Water Cyanotoxin Risk Communication Toolbox
  - Recreational Water Communication Toolbox for Cyanobacterial Blooms
  - Monitoring and Responding to Cyanobacteria and Cyanotoxins in Recreational Water

Assessments

- EPA conducts monitoring and assessments to know the status of the nation's waters.
- Assessments
  - Analytical methods developed for cyanotoxins in drinking and surface waters.
  - Unregulated Contaminant Monitoring Rule (UCMR) 4 for cyanotoxins in drinking water public systems from 2018 to 2020.
  - National Aquatic Resource Surveys (NARS) for cyanotoxins and cyanobacteria indicators in lakes, rivers/streams, coastal waters and wetlands.

Outreach and Partnerships

- EPA also participates in working groups and coordinates with Federal Agencies and others to improve communications and to expand stakeholder engagement.
- Outreach and Partnerships
  - Cyanobacteria Assessment Network (CyAN) Project
  - EPA's Cyanobacteria HABs Webpage
  - Freshwater HABs Newsletter
  - Stakeholder Engagement through webinars and workshops
  - Mississippi River/Gulf of Mexico Watershed Nutrient Task Force (Hypoxia Task Force or HTF)
  - IWG- HABHRCA

Research

EPA's research on the assessment and management of HABs and their toxins is mainly conducted by the Office of Research and Development (ORD).

ORD's Safe and Sustainable Water Resources Research Program is organized into three areas:

1. Assessing Adverse Health Outcomes from Exposure to HABs
2. Supporting Management of HABs and Their Impacts in Source Water and Drinking Water
3. Developing Tools to Support HABs Risk Characterization and Assessment

Thanks for your attention!

EPA's CyanoHABs in Water Bodies Website
www.epa.gov/cyanohabs

EPA's Harmful Algal Blooms Webpage
www.epa.gov/nutrientpollution/harmful-algal-blooms

EPA's Harmful Algal Blooms and Cyanobacteria Research Webpage
www.epa.gov/water-research/harmful-algal-blooms-and-cyanobacteria-research

NCCOS NATIONAL CENTERS FOR COASTAL OCEAN SCIENCE

NOAA HAB Response Capabilities

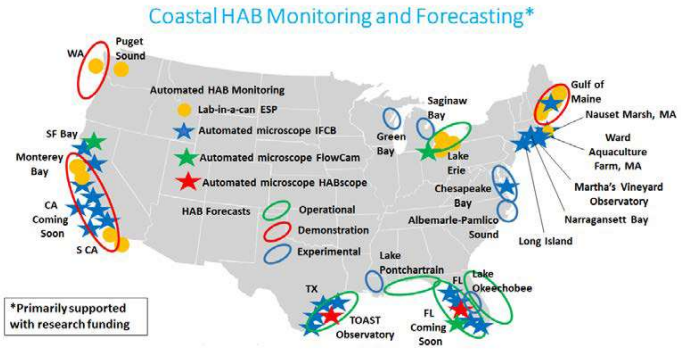
Kaytee Pokrzywinski (Boyd)
NOAA National Ocean Service
National Centers for Coastal Ocean Science
HAB Forecasting Branch Chief

SCIENCE SERVING COASTAL COMMUNITIES

NCCOS NATIONAL CENTERS FOR COASTAL OCEAN SCIENCE

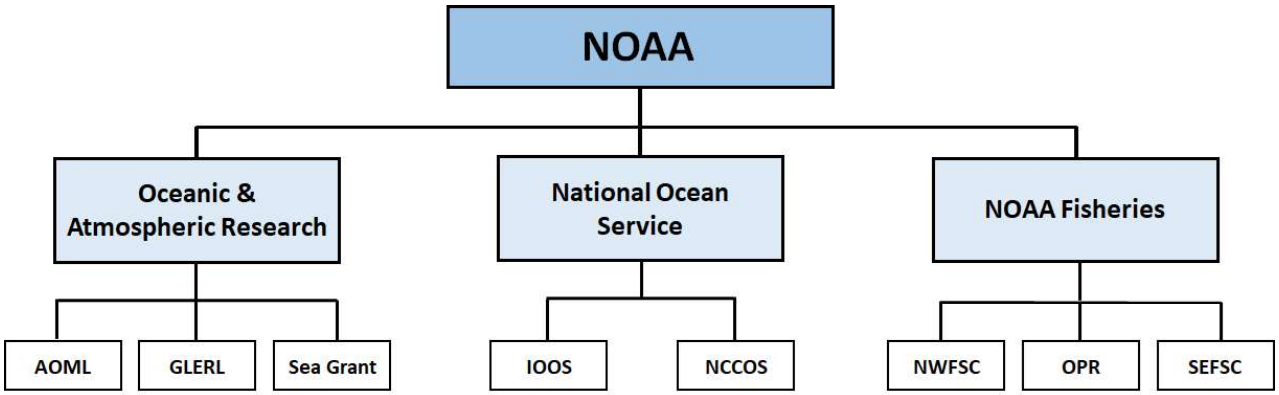
Capabilities and Assets

- National and regional scale capabilities
  - targeted areas
- HAB research through internal science capabilities and external programs
- HAB observing, modeling, and research capabilities and assets provide the foundation for:
  - Understanding HABs
  - Observing and forecasting
- Serve as early warning systems
  - Assets alert coastal managers to blooms before they cause damage



NCCOS NATIONAL CENTERS FOR COASTAL OCEAN SCIENCE

NOAA Offices and Programs



Red tide & water quality research
Great Lakes HAB monitoring & research
Extramural Coastal & Great Lakes HAB efforts

**AOML: Atlantic Oceanographic & Meteorological Laboratory*
**GLERL: Great Lakes Environmental Research Laboratory*

National HAB Observing Network (NHABON)
IOOS Regional Associations
HAB Forecasting/Monitoring
Extramural HAB Response Funding to States/Tribes
HAB Competitive Research Programs

**IOOS: Integrated Ocean Observing System*
**NCCOS: National Centers for Coastal Ocean Science*

Marine HAB research (W coast, *Pseudo-nitzschia*)
Biotoxins in shellfish/marine mammals
Mammal Mammal Health & Mortality
Tribal interactions
Red tide & fisheries/protected species research

**NWFSC: Northwest Fisheries Science Center*
**OPR: Office of Protected Resources*
**SEFSC: Southeast Fisheries Science Center*

NCCOS NATIONAL CENTERS FOR COASTAL OCEAN SCIENCE

NOAA Immediate Response Resources

HAB Event Response Program*

- Immediate assistance for planning response and advancing the understanding of HABs
- Tap into NCCOS resources, rapidly mobilize expertise, quickly reimburse costs

Analytical Response Team

- Primary responders to HABs and associated mortality events, providing rapid and accurate identification of harmful algae and their associated toxins.

HAB Monitoring System*

- Deliver near real-time products for use in locating, monitoring and quantifying algal blooms in coastal and lake regions of the US.

Office of Protected Resources

- Responds to and investigates the causes of unusual mortality events, which are sometimes a result of HABs

Phytoplankton Monitoring Network

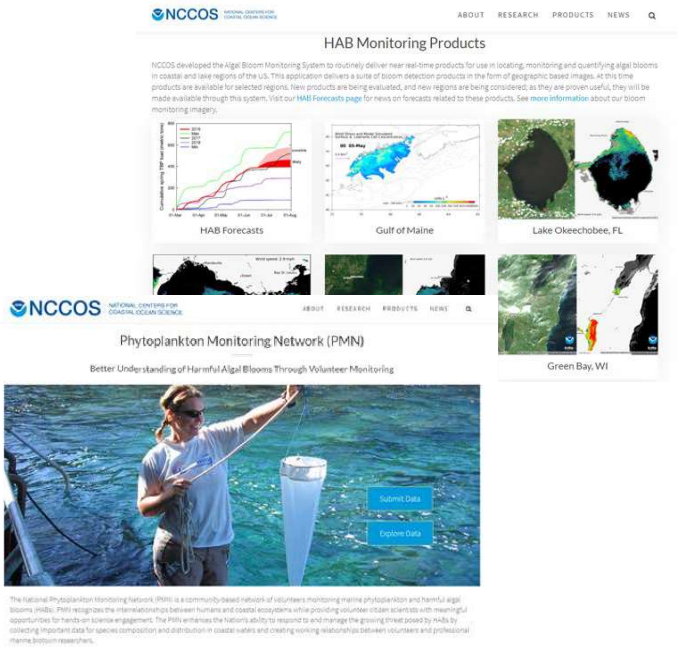
- Community-based network that collects data for species composition and distribution in coastal waters
- Creates working relationships between volunteers and professional marine biotoxin researchers.

Regional Specific Responses

- Regionally based centers, labs, and associations can provide immediate response support in their region depending on their capacity

* Please see posters on these resources

Examples of immediate response support

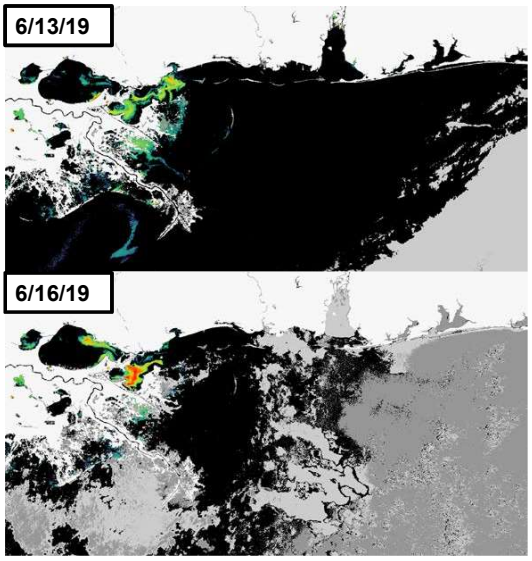


- Satellite imagery
  - Provided to teams prior to sampling for bloom tracking
  - Website links created
- HAB species identified and toxin samples analyzed by ART and PMN
- Funding and Guidance
  - Technical guidance, advice, and Effective messaging
  - Funding
- Response and cause determination for marine mammal mortalities

NCCOS NATIONAL CENTERS FOR COASTAL OCEAN SCIENCE

Immediate Response Example

- Cyanobacterial bloom in Lake Pontchartrain and the northern Gulf of Mexico
  - July -Sept 2019
- NOAA Response
  - Training for field identification
  - Initial cyanobacterial identification and toxin analysis
  - $25K funding for sample collection and analysis
  - Daily satellite imagery to track bloom
  - Technical and effective messaging guidance
- Weekly Interstate and interagency coordination calls
  - Academic, NGO, State, and Federal representation



NCCOS NATIONAL CENTERS FOR COASTAL OCEAN SCIENCE

Conclusion and Links for more information

NOAA resources include immediate response capabilities and HAB observing, modeling, and research capabilities already in place in impacted regions

Links for immediate response resources

- HAB Event Response Program
- Analytical Response Team
- Phytoplankton Monitoring Network
- HAB Monitoring System

NCCOS Contacts

- David Kidwell – Director, Competitive Research Program
- Kaytee Pokrzywinski (Boyd) – Chief, HAB Forecasting Branch

NIH National Institute of Environmental Health Sciences
Your Environment. Your Health.

NIEHS Response to Harmful Algal Bloom Events

Frederick L. Tyson, Ph.D.

Genes Environment and Health Branch
Division of Extramural Research and Training
National Institute of Environmental Health Sciences

April 27, 2021
Research Triangle Park

Strategic Themes for Environmental Health Sciences 2018-2023

National Institute of Environmental Health Sciences
Your Environment. Your Health.

Grantees supported by NIEHS to conduct research on:

NOAA

National Institutes of Health
U.S. Department of Health and Human Services

NIEHS HABs Research Support

- **NIEHS partnership with the National Science Foundation (NSF)**
  - P30 WHOI saxitoxin and DA
  - P30 Florida Gulf Coast and USA - Ciguatera toxin
  - P30 Bowling Green State University – Microcystin
  - P30 University of South Carolina - Microcystin
  - R01 University of Washington - Domoic Acid

- **NIEHS research grants independent of NSF collaboration**
  - R21 UCSD Biosynthesis of Cyanobacterial toxin Anatoxin-a
  - Time Sensitive R21 Roskamp Institute Long term assessment of neurological effects after red tide exposure

Photo Credit: Greater Caribbean Center for Ciguatera Research, Mike Parsons

National Institute of Environmental Health Sciences
Your Environment. Your Health.

Training Programs

- F31 Brunson UCSD Transcriptional regulation of Domoic Acid biosynthesis
- F31 Mudge Novel methods for predicting HAB bloom events based on microbiota and proteomics (pending)
- F32 Fallon UCSD Biosynthetic pathway of ladder-frame polyether toxins using computational, genomic, transcriptomic and metabolomic approaches
- Diversity Supplement to WHOI P30 for Domoic Acid mechanism of developmental neurotoxicity

National Institutes of Health
U.S. Department of Health and Human Services

U.S. Fish and Wildlife Service

Natural Resource Program Center
National Wildlife Refuge System

Harmful Algal Bloom Preparedness & Response

U.S. Fish & Wildlife Service Overview

Michael Higgins
Water Resources Coordinator
National Wildlife Refuge System, USFWS
Natural Resource Program Center
Fort Collins, Colorado

Harmful Algal Bloom Preparedness and Response Workshop
April 27, 2021

U.S. Fish and Wildlife Service

Natural Resource Program Center
National Wildlife Refuge System

U.S. Fish & Wildlife Service Mission

"Work with others to conserve, protect and enhance fish, wildlife and plants and their habitats for the continuing benefit of the American people"

Relevant USFWS Programs

- Ecological Services –Endangered Spp.
- Fish and Aquatic Conservation
- Migratory Birds
- National Wildlife Refuge System
- Science Applications

U.S. Fish and Wildlife Service
Natural Resource Program Center
National Wildlife Refuge System

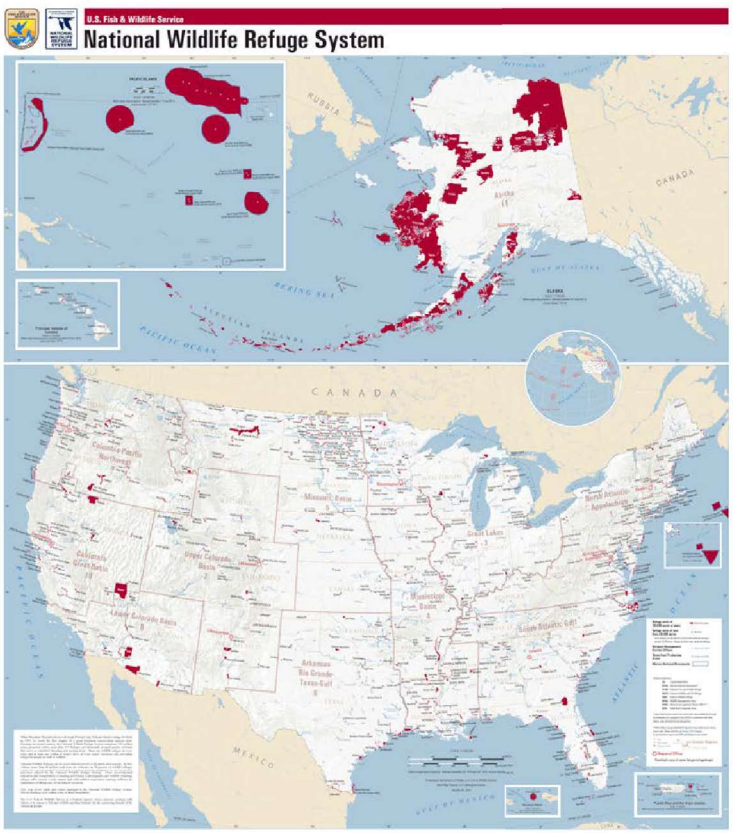
National Wildlife Refuge Mission

The mission of the National Wildlife Refuge System is to administer a national network of lands and waters for the conservation, management and, where appropriate, restoration of the fish, wildlife and plant resources and their habitats within the United States for the benefit of present and future generations of Americans.

National Wildlife Refuge System

- "Wildlife First" Mission
- 567 National Wildlife Refuges
- 38 Wetland Management Districts
- Over 36,ooo Waterfowl Production Areas (WPAs)
- 95 million land acres
- 760 million acres submerged lands and waters (including 5 marine national monuments)

U.S. Fish and Wildlife Service



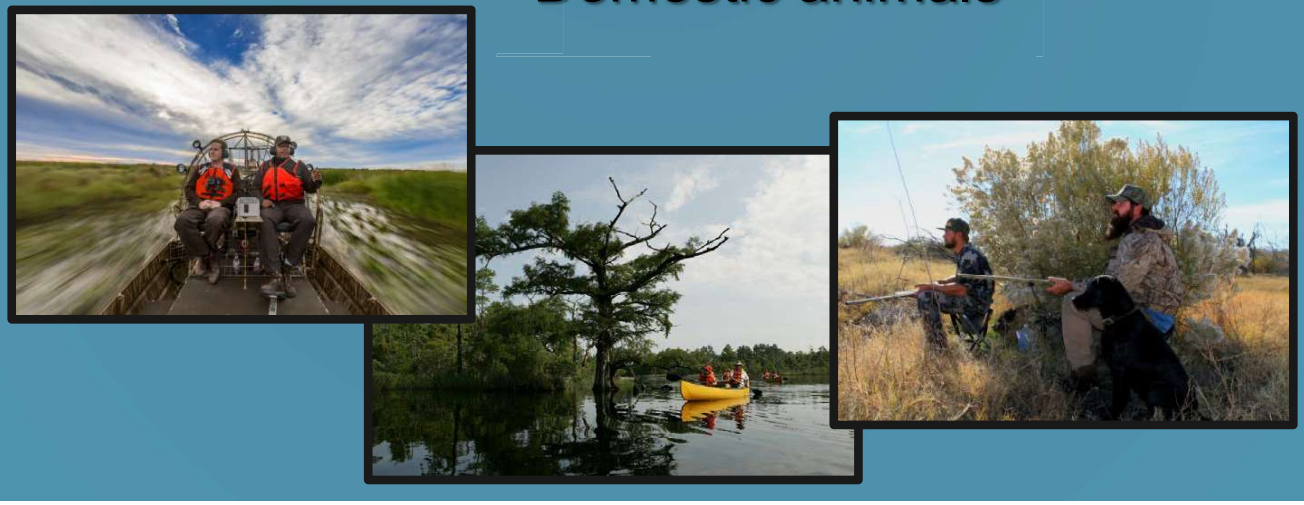
USFWS Role in HABs Monitoring & Response

- Statutory requirement for NWRS to ensure maintenance of "environmental health" and "adequate water quantity and quality"
- USFWS policies to maintain healthy wildlife populations and habitats
- Protect the health and safety of visitors and employees

U.S. Fish and Wildlife Service
Natural Resource Program Center
National Wildlife Refuge System

HABs Incidences Potentially Affecting

- Wildlife
- Visitors and pets
- Employees
- Domestic animals



Recurring HAB Incidences on NWRs

- Florida
- North Carolina
- Midwest/Lake Erie
- Dakotas
- California/Oregon

U.S. Fish and Wildlife Service
Natural Resource Program Center
National Wildlife Refuge System

HABs Preparedness

- Inreach: Employee awareness and safety
- Outreach: Visitors and adjacent landowners
- Water sampling kits and collection guidance
- Arrange laboratory analyses of water/tissue samples

U.S. Fish and Wildlife Service

Natural Resource Program Center
National Wildlife Refuge System

HABs Response

- HABs events may co-occur with other mortality events (e.g. botulism)
- Difficult to assign mortality specifically to cyanotoxins
- Partner with States and NWHC
- Mitigation: where practicable

Danielle Buttke

One Health Coordinator

National Park Service

National Park Service

- Founded 1916
- 423 units- equivalent to the 5th largest state
- 300-330 million visitors
- 20,000 employees, 300,000 volunteers

National Park Service Mission

" ..to conserve the scenery and natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."

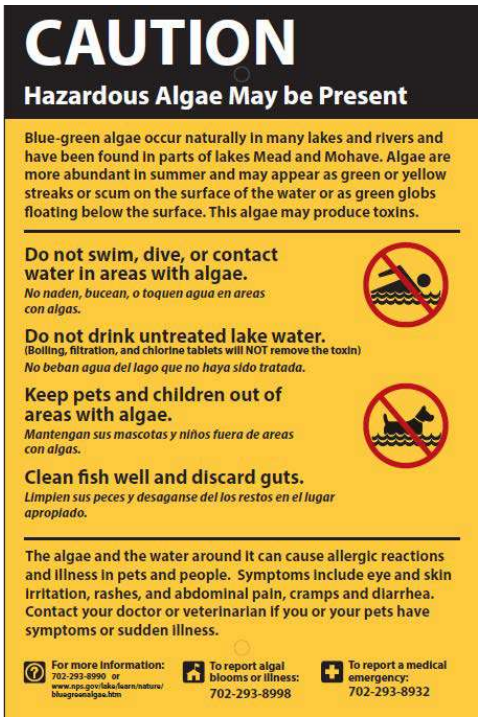
U.S.C. Title 54 100101 (a)

Response

- Wildlife die-offs
  - Coyotes, squirrels, ducks, tree frogs
- Visitor dog deaths
- Human illnesses
  - Rash, GI illness, suspected neurologic disease

Monitoring

- Recreational waters
- Drinking water systems
- Fish and shellfish



Research

- NPS
  - Biological Resources
  - Air Resources
  - Water Resources
- Partners
  - USGS
  - NOAA
  - State Health Departments
  - Citizen Science

Thanks!

The NPS One Health network: protecting and promoting the health of all species and the parks that we share.

USGS
science for a changing world

Harmful Algal Blooms
U.S. Geological Survey Science and Monitoring

Jennifer L. Graham

New York Water Science Center

Harmful Algal Bloom Preparedness and Response Workshop

April 27, 2021

U.S. Department of the Interior
U.S. Geological Survey

USGS

Mission: The USGS mission is to monitor, analyze, and predict current and evolving dynamics of complex human and natural Earth-system interactions and to deliver actionable intelligence at scales and timeframes relevant to decision makers.

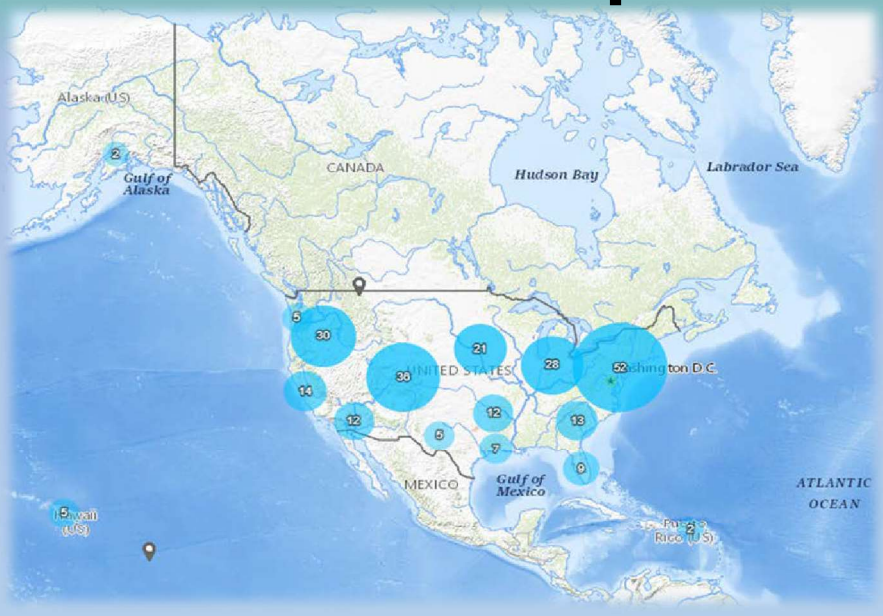
Vision: Lead the Nation in 21st century integrated research, assessments, and prediction of natural resources and processes to meet society's needs.

What Do We Do: As the Nation's largest water, earth, and biological science and civilian mapping agency, USGS collects, monitors, analyzes, and provides science about natural resource conditions, issues, and problems. Our diverse expertise enables us to carry out large-scale, multidisciplinary investigations and provide impartial scientific information to resource managers, planners, and other customers.

https://www.usgs.gov

USGS

USGS Footprint



https://www.usgs.gov/connect/locations

USGS

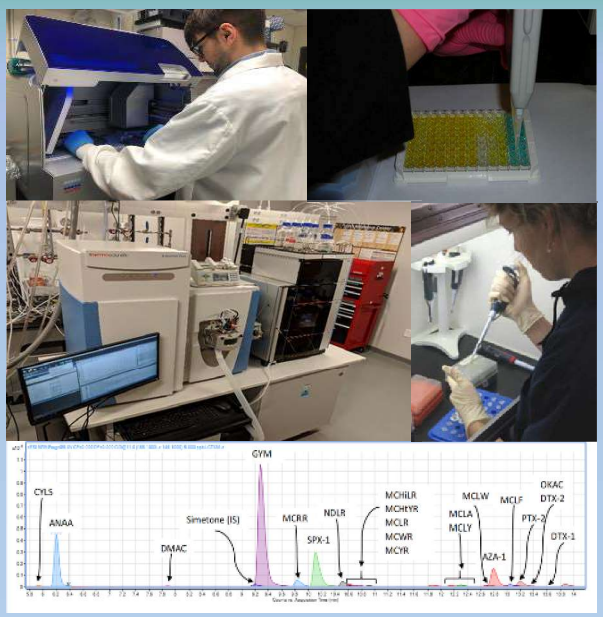
USGS Harmful Algal Bloom Science

- Developing field and laboratory methods to identify and quantify harmful algal blooms and associated toxins.
- Understanding occurrence, causal factors, environmental fate and transport, ecological processes, and effects of environmental exposure.
- Developing tools to inform management decisions.

USGS

USGS Laboratories

- USGS Algal and Other Environmental Toxins Laboratory
- USGS Michigan Bacteriological Research Laboratory
- USGS Ohio Water Microbiology Laboratory
- National Water Quality Laboratory

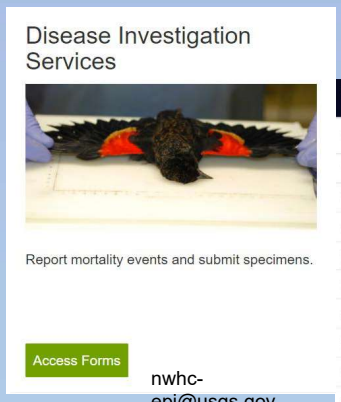


USGS Laboratories

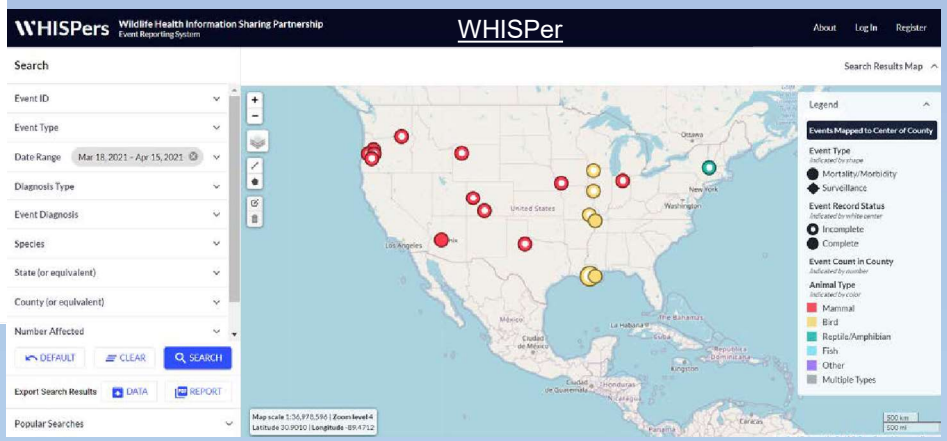
USGS

National Wildlife Health Center

Advancing wildlife health science for the benefit of animals, humans, and the environment



nwhc-epi@usgs.gov



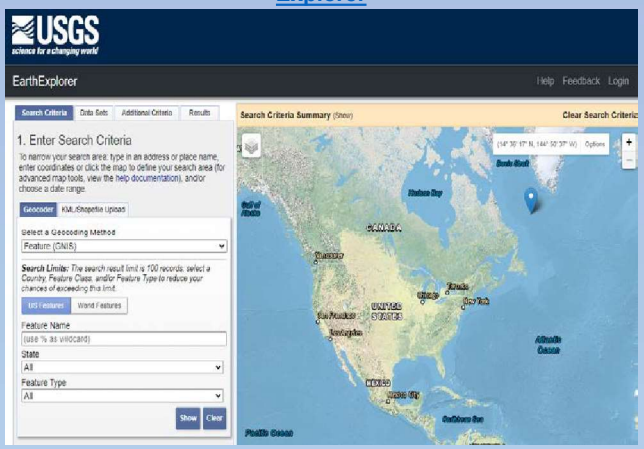
National Wildlife Health Center

USGS

USGS Observing Systems

National Water Dashboard

Earth Explorer



USGS

Harmful Algal Bloom Event Response

- USGS does not have a mandate for harmful algal bloom response.
- USGS often provides technical expertise during events.
- USGS occasionally assists with data collection during events.

USGS

Additional Information

Toxins and Harmful Algal Blooms Science Team

Next Generation Water Observing System

Harmful Algal Bloom Cooperative Matching Funds Projects

Jennifer Graham
jlgraham@usgs.gov

USGS

HARMFUL ALGAE BLOOM RESPONSE AT USACE MANAGED RESERVOIRS

Tony Clyde, Ph.D., CLM
Limnologist
USACE, Tulsa District
Operations Division
Natural Resource Management Section

27 APR 2021

Tony.Clyde@usace.army.mil

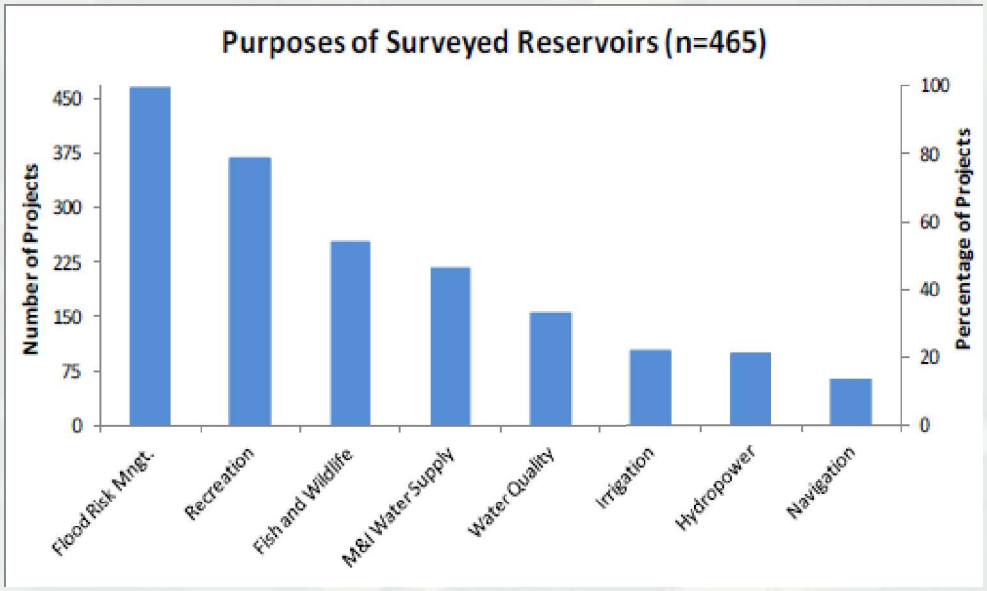
US Army Corps of Engineers®

Why are HABs a concern to USACE?

- 402 lakes in 43 states
  - hosting 33% of all fresh water fishing
  - 4,628 recreation areas
    - 80% within 50 miles of a large U.S. city
- 7,829,605 acres of land and 5,630,584 acres of water under USACE management (~ 2% of all federal lands)
  - Hosting 20% of visits on federal lands
  - 56,000 miles of shoreline; 5,045 recreation areas; 91,583 campsites; 2,129 playground sites; 887 designated swimming areas; 7,684 miles of hiking trail; 3,713 boat ramps; 109,057 marina slips
- 262,158,492 total visits (person-trips) in FY19
- 7,929,935 acre-feet of water supply in FY17
  - 6,212,233 currently under contract (95.7%)
  - 5,063 mgd yield currently under contract

Source: Value to the Nation – https://www.iwr.usace.army.mil/Missions/Value-to-the-Nation/'/

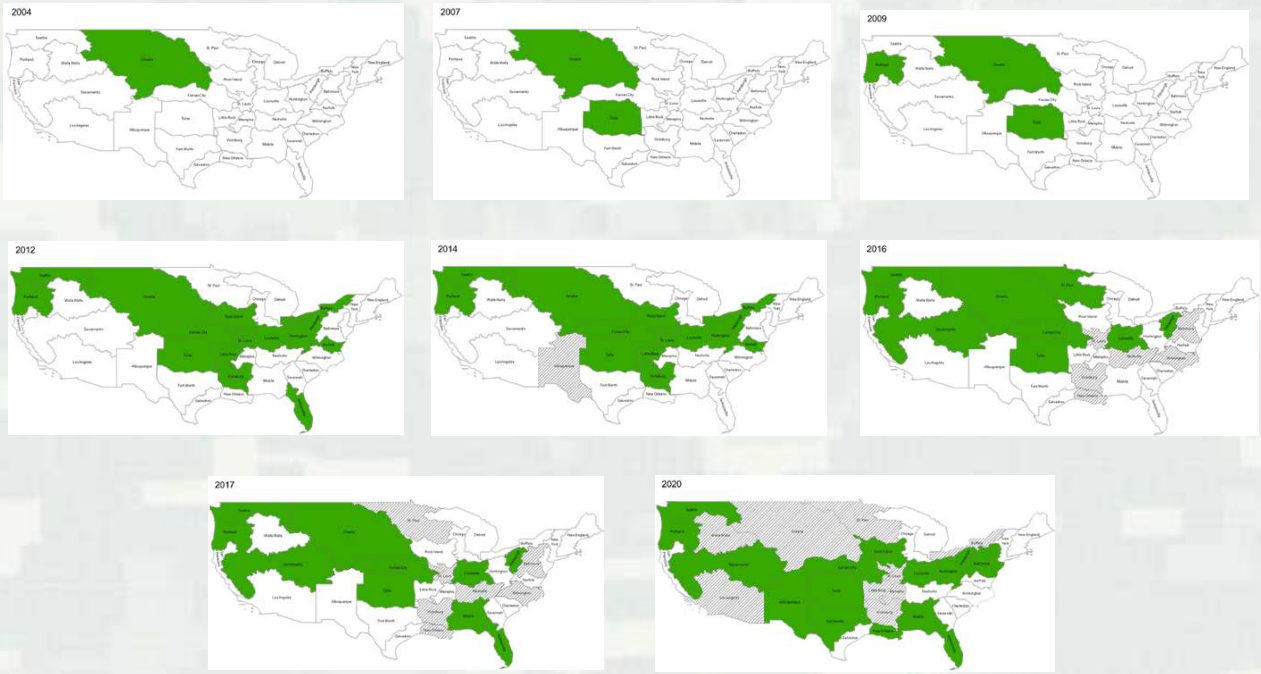
Project Authorizations for Operational USACE Civil Works Projects



Source: National Portfolio for Reallocations Assessment of Data: Status and Challenges for USACE Reservoirs, 2016-RES-01, USACE Institute of Water Resources, May 2016

BUILDING STRONG®

Progression of HABs impacting USACE 2004 - 2020



Green: Districts reporting HABs Gray: Districts reporting in, but NO HABs White: No district report

BUILDING STRONG®

HAB experiences of USACE

- Types of HABs experienced
  - Cyanobacteria, Pyrmnesium parvum, Dinoflagelates
- Location of HABs within the waterbody
  - Entire waterbody, coves/shorelines only, mixture of both
- Adversely impacted missions
  - Primarily Recreation and Fish and Wildlife; Secondarily Water Supply; Water Quality; Flood Control
- Impacts to Lake Office Operations and Staff
  - Requests for operational changes; increased monitoring assistance requests; increased need for public outreach; increased visitor assistance; frequent closures/advisories
- Public concerns expressed related to:
  - Economic impacts; negative social media and news coverage; pet/animal/wildlife deaths; human illnesses

HAB driven technical and R&D requests submitted by Districts to ERDC

- Statements of Need
  - 2008 Tools Useful in Testing Preventative Management Strategies of HABs in Surface Waters
  - 2017 Non-Invasive Harmful Algal Bloom (HAB) Remediation Strategies
  - 2019 Operational Strategies for HAB Management in Inland Reservoirs (ongoing R&D)
  - 2020 In-Situ Evaluation of Peroxide Treatments Applied to Harmful Cyanobacteria Blooms
  - 2021 Characterization of Harmful Algal Blooms using 40 Years of Geospatial Data
- Water Operations Technical Support
  - 2011 – Remote Sensing for Inland Water Quality Monitoring: A U.S. Army Corps of Engineers Perspective (ERDC/TN TR-1-13)
  - 2014 - HAB Workshop, NWP resulted in HAB questionnaire and to be published TN to update ERDC/TN ANSRP-09-1.
  - 2017 Review and Evaluation of Reservoir Management Strategies for Harmful Algal Blooms (ERDC/TN TR-17-11)

HAB driven legislative requirements

- WRDA 2018 (PL) Sec. 1109 Harmful Algal Bloom Technology Demonstration
  - (a) IN GENERAL.—The Secretary, acting through the Engineer Research and Development Center, shall implement a 5-year harmful algal bloom technology development demonstration program under the Aquatic Nuisance Research Program. To the extent practicable, the Secretary shall support research that will identify and develop improved strategies for early detection, prevention, and management techniques and procedures to reduce the occurrence and effects of harmful algal blooms in the Nation's water resources.
  - (b) SCALABILITY REQUIREMENT.—The Secretary shall ensure that technologies identified, tested, and deployed under the harmful algal bloom technology development demonstration program have the ability to scale up to meet the needs of harmful-algal-bloom related events.

- WRDA 2020 (PL 116-133) Sec. 128 Harmful Algal Bloom Demonstration Program
  - (a) IN GENERAL.—The Secretary shall carry out a demonstration program to determine the causes of, and implement measures to effectively detect, prevent, treat, and eliminate, harmful algal blooms associated with water resources development projects.
  - (c) FOCUS AREAS.—In carrying out the demonstration program under subsection (a), the Secretary shall undertake program activities related to harmful algal blooms in the Great Lakes, the tidal and inland waters of the State of New Jersey, the coastal and tidal waters of the State of Louisiana, the waterways of the counties that comprise the Sacramento-San Joaquin Delta, California, the Allegheny Reservoir Watershed, New York, and Lake Okeechobee, Florida.
  - (d) ADDITIONAL FOCUS AREAS.—In addition to the areas described in subsection (c), in carrying out the demonstration program under subsection (a), the Secretary shall undertake program activities related to harmful algal blooms at any Federal reservoir located in the Upper Missouri River Basin or the North Platte River Basin, at the request and expense of another Federal agency.
  - Requires USACE to consult with the heads of other Federal agencies and to make maximum use of existing Federal and State data as well as ongoing programs.

Harmful Algal Bloom (HAB) Preparedness & Response Workshop

April 27, 2021

CAPT Renée Funk, DVM, MPH&TM, MBA, DACVPM

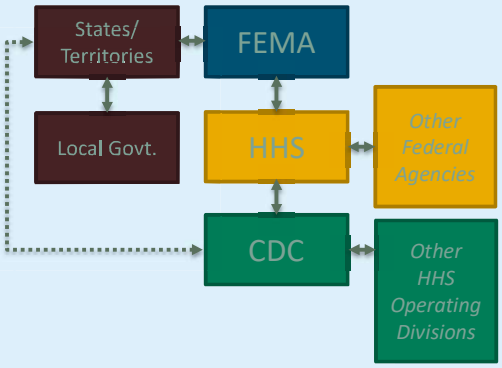
Associate Director for Emergency Management

National Center for Environmental Health/Agency for Toxic Substances and Disease Registry (NCEH/ATSDR)

Centers for Disease Control and Prevention (CDC)

CDC's Role – Public Health and Medical Services

- **Emergency Support Function (ESF) 8:** Public Health and Medical Services
  - Mechanism for coordinated Federal assistance
  - Supplemental assistance to State, tribal, and local governments in core functional areas



What is CDC Doing to Respond?

Epidemiology & Health Surveillance	Environmental Health	Communication
Media Mortality tracking	Private & public water coordination	Disseminate timely and accurate information
Shelter surveillance	Vector control	News & social media tracking
Community Needs Assessment	Mold remediation & CO exposure	Rumor control
Syndromic surveillance	Occupational health	Partner messaging
TA to state/local health depts.		

Unique Aspects of Environmental Emergencies

- Wide range of health and safety concerns in environmental emergencies, each requiring different expertise and resources
- Coordination with many partners, including health and non-health partners
- Specific challenges related to non-infectious outbreaks

Wide Range of Health and Safety Concerns

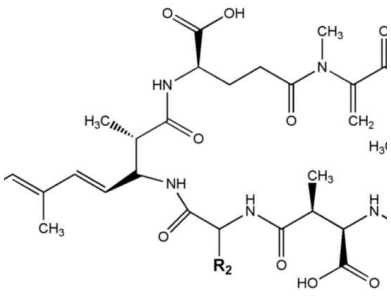
- Injuries and illnesses
  - Lack of access to medical care
  - Unusual set of symptoms/syndromes/clinical presentations from various chemical or warfare agents
  - Direct and indirect injuries and illnesses, including mental health
  - Latent health effects (e.g., thyroid cancer)
- Environmental concerns (e.g., sanitation, power outage, mold, radionuclides, chemical contamination, vectors)
- Access to safe food and water
- Evacuation issues

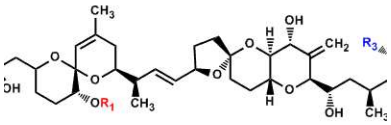
Stacey Wiggins, Ph.D.
Division of Seafood Safety/Office of Food Safety
Center for Food Safety & Applied Nutrition
Food & Drug Administration

HAB PREPAREDNESS AND RESPONSE
FDA ROLES AND RESPONSIBILITIES

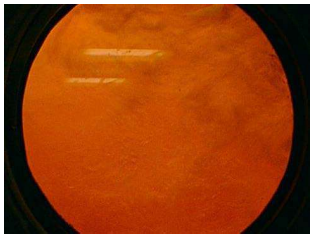
FDA Mission

The **FDA** is responsible for protecting the public health by assuring the safety, efficacy, and security of human and veterinary drugs, biological products, medical devices, our nation's food supply, cosmetics, and products that emit radiation.





	R_1	R_2	R_3
OA	H	H	CH_3
DTX1	H	CH_3	CH_3
DTX2	H	CH_3	H
7-O-Acyl	Ac	same as above	

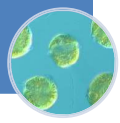


Harmful Algal Blooms **Toxins**

Marine Toxins

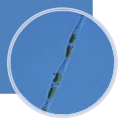
Saxitoxins
- Tingling
- Numbness
- Weakness

PSP



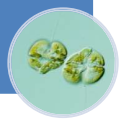
Domoic Acid
- Vomiting
- Diarrhea
- Confusion

ASP



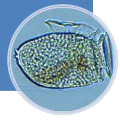
Brevetoxins
- Tingling
- Aches
- Dizziness

NSP



Okadaic acids
- Vomiting
- Diarrhea
- Nausea

DSP

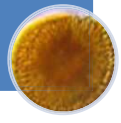


Azaspiracids
- Vomiting
- Nausea
- Cramps

AZP

Ciguatoxins
- Hot/Cold Reversals
- Nausea
- Tingling
- Arrhythmia

CFP



Freshwater Toxins

Neurotoxins
- Anatoxins
- Saxitoxins

Hepatotoxins
- Cylindrospermopsin
- Microcystins
- Nodularin

Dermatoxin
- Lyngbyatoxin

Dermatoxins & Gastrointestinal Toxins
- Aplysiatoxin
- Debromoaplysiatoxin

FDA-Regulated Products

Seafood
Bottled water
Produce/Irrigation Water
Water for Food Processing
Dietary Supplements

Regulations

- **Federal Food, Drug, and Cosmetic Act (FD&C)**
  - Sec. 402 Adulterated Food
- **Code of Federal Regulation (21 CFR)**
  - Part 111 Current good manufacturing practices for dietary supplements
  - Part 117 Subpart B Current good manufacturing practice for seafood and water for food processing
  - Part 123 Fish and fishery products (Seafood HACCP)
  - Part 129 Current good manufacturing practices for bottled water
  - Part 165.110 Standard of quality for bottled water

Marine Biotoxin Guidance Levels

- **Paralytic Shellfish Poisoning (PSP)**
  - ≥ 80 µg/100 grams
- **Neurotoxin Shellfish Poisoning (NSP)**
  - ≥ 0.8 mg/kg BTX-2 eq (20 MU/100 grams)
- **Azaspiracid Shellfish Poisoning (AZP)**
  - ≥ 0.16 mg/kg AZA-1 eq
- **Diarrhetic Shellfish Poisoning (DSP)**
  - ≥ 0.16 mg/kg total okadaic acid eq
- **Amnesic Shellfish Poisoning (ASP)**
  - ≥ 20 mg/kg domoic acid
  - > 30 mg/kg domoic acid for Dungeness crab viscera
- **Ciguatera Fish Poisoning (CFP)**
  - ≥ 0.01 g/kg P-CTX-1 eq
  - ≥ 0.1 µg/kg C-CTX-1 eq

Interstate Shellfish Sanitation Conference (ISSC)

- Fosters and promotes shellfish sanitation through cooperation
  - FDA, NOAA (NMFS), EPA, states, industry, academia
- Shellfish covered
  - Oysters, clams, mussels [scallops, except when adductor only]
  - Shucked or in shell, raw (including PHP), frozen or unfrozen, whole or in part
- http://www.issc.org

National Shellfish Sanitation Program (NSSP)

- Cooperative program for the sanitary control of shellfish
- Guide for the Control of Molluscan Shellfish
- The NSSP Guide is revised every two years through a proposal process
- The NSSP Guide includes guidance but also the Model Ordinance, which may be adopted as regulation by states

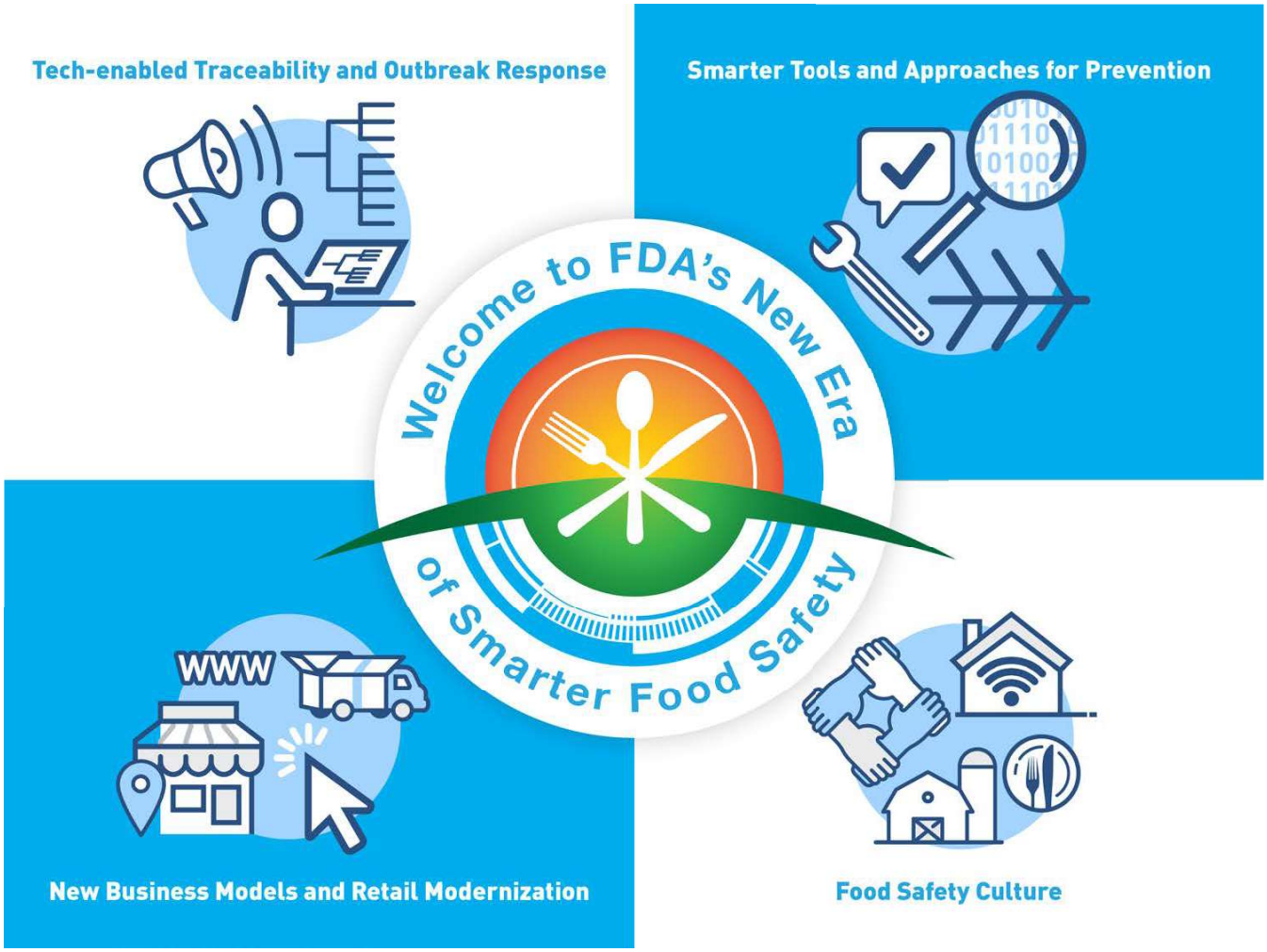
Prevention

Placing molluscan shellfish growing areas in the closed status

If Molluscan Shellfish Contamination Occurs

- Communicate with states, federal partners, and ISSC
- Monitor the recall
- Provide technical assistance
- Ensure reopening criteria are met
  - NSSP Conforming Laboratory
  - NSSP Approved Method

Emerging Issues	Assessing and evaluating newly identified potential seafood hazards
Prevention	Identifying strategies to improve the control of seafood contamination
Response	Developing systematic approaches for monitoring incidences of contamination
Partnerships	Strengthening relations with international, federal, state, local, tribal, and territorial agencies



FEMA Response to Disasters that may Include Hazard Algal Blooms (HABs)

Joselito Ignacio, MA, MPH, CIH, CSP, REHS
Public Health Advisor
CBRN Office, Response Directorate
Office of Response and Recovery

27 April 2021

FEMA

For Official Use Only

FEMA's Role

- Managing the efficient and timely delivery of Federal disaster relief to support and supplement the efforts and capabilities of State, tribal, territorial, local (STTL) and insular area governments; eligible nonprofit organizations; and individuals affected by a declared major disaster or emergency.
- Authorized by the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act), Sandy Recovery Improvement Act (SRIA), Post Katrina Emergency Management Reform Act (PKEMRA), and the Homeland Security Act (HS

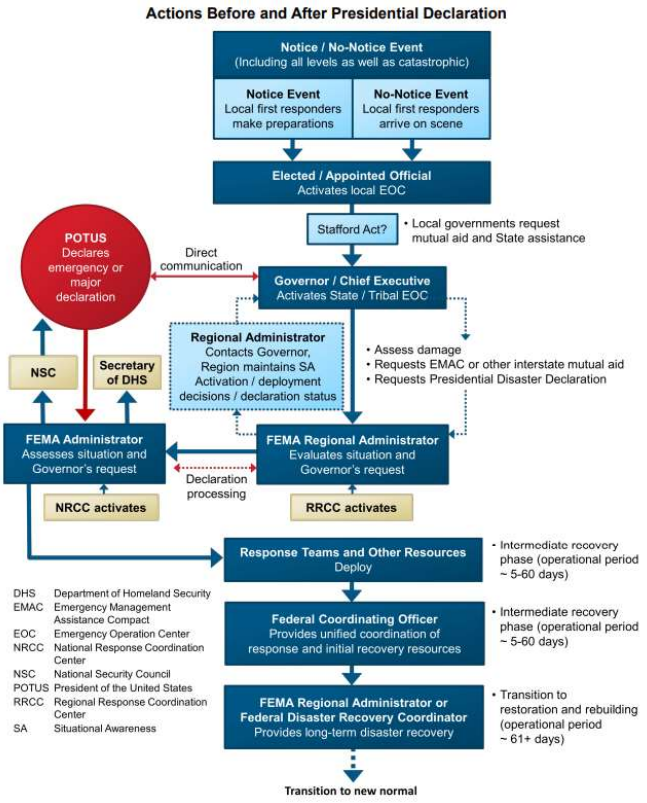
FEMA

FEMA Involvement in Major Incident

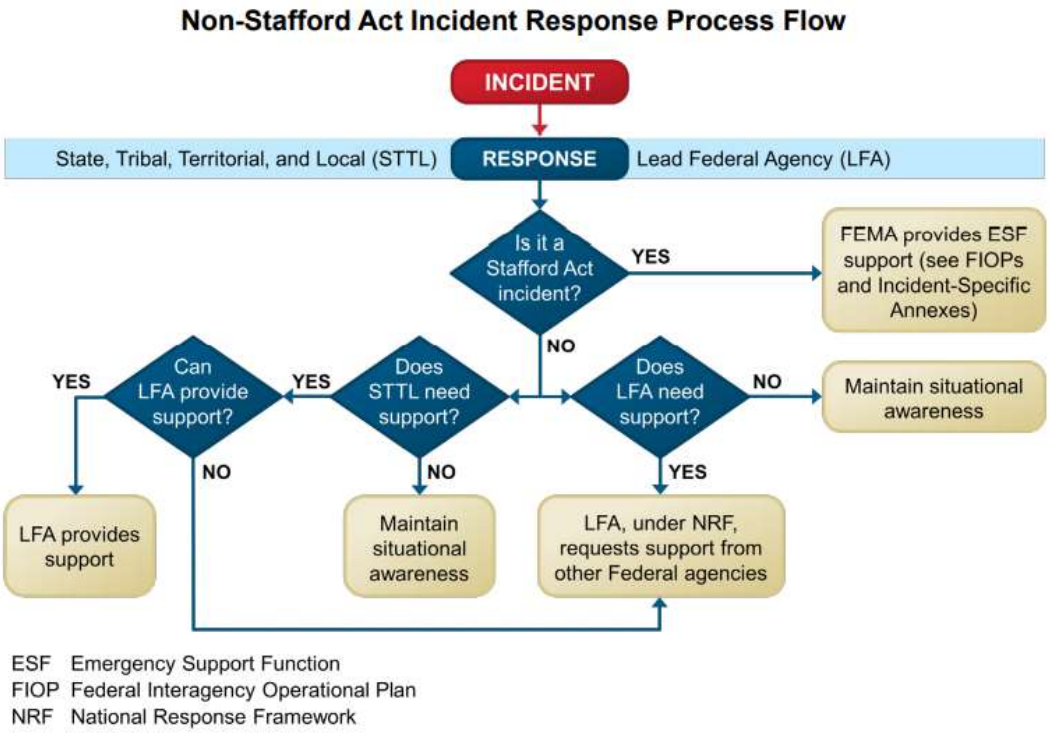
	Stafford Emergency/ Disaster Declaration	Non-Stafford/ Federal-to-Federal Assistance
Supported Entity	**State/Tribal/Territorial/ Local Jurisdictions**	**Lead Federal Agency/Authority**
Funding Source	**Disaster Relief Funds (DRF)**	**Inter Agency Agreement (IAA) with Lead Federal Agency/Authority**

Stafford Act Declarations

Emergency Declaration	**Definition** Any occasion or instance for which, in the determination of the President, Federal assistance is needed to supplement State and local efforts and capabilities to save lives and to protect property and public health and safety, or to lessen or avert the threat of a catastrophe in any part of the United States (42 U.S.C. § 5122(1)). **FEMA Assistance** Assistance usually < $5 million; limited to immediate and short-term assistance essential to save lives and protect public health, safety, and property.
Major Disaster Declaration	**Definition** Any natural catastrophe (including any hurricane, tornado, storm, high water, wind-driven water, tidal wave, tsunami earthquake, volcanic eruption landslide, mudslide snowstorm, or drought), or, regardless of cause, any fire, flood, or explosion, in any part of the United States, which in the determination of the President causes damage of sufficient severity and magnitude to warrant major disaster assistance under this Act to supplement the efforts and available resources of States, local governments, and disaster relief organizations in alleviating the damage, loss, hardship, or suffering caused thereby (42 U.S.C. § 5122(2)). **FEMA Assistance** Triggers involvement of some/all of FEMA's disaster assistance and grant programs: Individual Assistance (IA), Public Assistance (PA), and Hazard Mitigation Assistance.

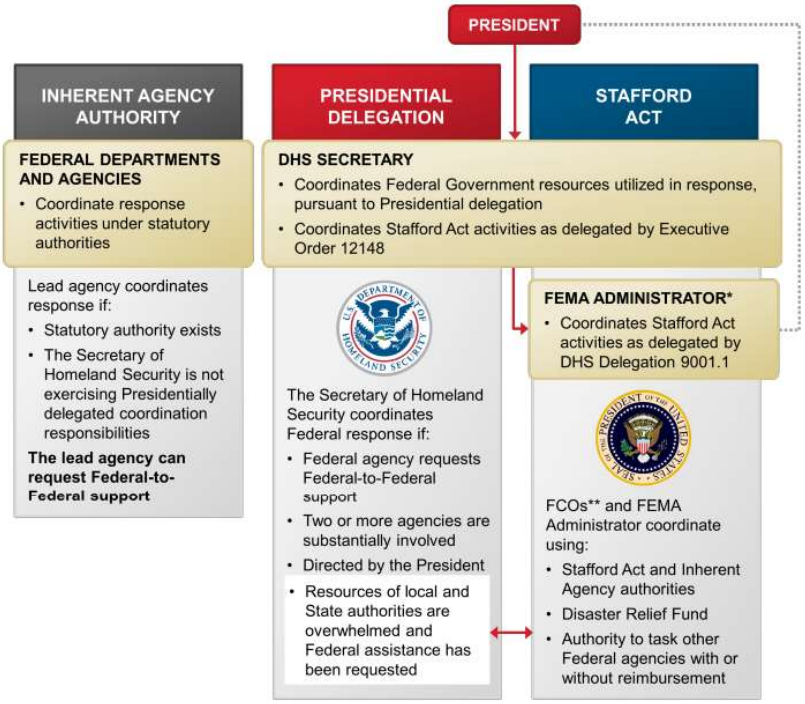

Actions Before and After Presidential Declaration
Notice / No-Notice Event
(Including all levels as well as catastrophic)
Notice Event
Local first responders make preparations
No-Notice Event
Local first responders arrive on scene
Elected / Appointed Official
Activates local EOC
Stafford Act?
• Local governments request mutual aid and State assistance
POTUS
Declares emergency or major declaration
Direct communication
Governor / Chief Executive
Activates State / Tribal EOC
Regional Administrator
Contacts Governor, Region maintains SA
Activation / deployment decisions / declaration status
• Assess damage
• Requests EMAC or other interstate mutual aid
• Requests Presidential Disaster Declaration
NSC
Secretary of DHS
FEMA Administrator
Assesses situation and Governor's request
FEMA Regional Administrator
Evaluates situation and Governor's request
Declaration processing
NRCC activates
RRCC activates
Response Teams and Other Resources
Deploy
• Intermediate recovery phase (operational period ~ 5-60 days)
Federal Coordinating Officer
Provides unified coordination of response and initial recovery resources
• Intermediate recovery phase (operational period ~ 5-60 days)
FEMA Regional Administrator or Federal Disaster Recovery Coordinator
Provides long-term disaster recovery
• Transition to restoration and rebuilding (operational period ~ 61+ days)
Transition to new normal
DHS Department of Homeland Security
EMAC Emergency Management Assistance Compact
EOC Emergency Operation Center
NRCC National Response Coordination Center
NSC National Security Council
POTUS President of the United States
RRCC Regional Response Coordination Center
SA Situational Awareness

FEMA


Non-Stafford Act Incident Response Process Flow
INCIDENT
State, Tribal, Territorial, and Local (STTL)
RESPONSE
Lead Federal Agency (LFA)
Is it a Stafford Act incident?
YES
FEMA provides ESF support (see FIOPs and Incident-Specific Annexes)
NO
Can LFA provide support?
YES
Does STTL need support?
YES
Does LFA need support?
NO
Maintain situational awareness
NO
NO
YES
LFA provides support
Maintain situational awareness
LFA, under NRF, requests support from other Federal agencies
ESF Emergency Support Function
FIOP Federal Interagency Operational Plan
NRF National Response Framework

FEMA

Incident Management Authorities



* The FEMA Administrator has additional standing authority for response under the Homeland Security Act and Title VI of the Stafford Act. Per the Homeland Security Act, the FEMA Administrator serves as the principal advisor to the President, Home Security Council, and Secretary of Homeland Security.

** The Federal Coordinating Officer (FCO) is appointed under Section 302 of the Stafford Act.

FEMA

Summary

- FEMA can play a role in either supporting impacted communities or the designated Lead Federal Authority in a Hazard Algal Bloom event

- Two types of responses: Stafford and Non-Stafford Acts
  - ❑ Stafford Act – Direct Federal assistance to impacted communities
  - ❑ Non-Stafford Act – Support to the Lead Federal Authority

FEMA

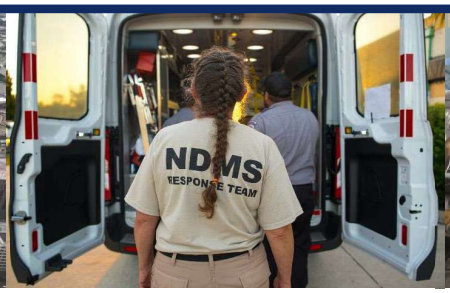
ASPR Role in Response and Recovery

Leremy Colf, Ph.D.
Current Operational Planning Branch Chief

Office of the Assistant Secretary for Preparedness and Response
U.S. Department of Health and Human Services

Health Security Threat Landscape

An Increasingly COMPLEX & UNPREDICTABLE World



ASPR's Purpose: UNITY OF COMMAND

Bringing Together Federal and Civilian Public Health & Medical Preparedness and Response Functions under One Agency

Pandemic and All-Hazards Preparedness Act (2006)


ASPR Mission

Save Lives and Protect Americans from Health Security Threats


Emergency Support Functions (ESFs)

#1. Transportation
Department of Transportation

#2. Communications
Department of Homeland Security

#3. Public Works and Engineering
Department of Defense/U.S. Army Corps of Engineers

#4. Firefighting
Department of Agriculture/Forest Service

#5. Information and Planning
Federal Emergency Management Agency

#6. Mass Care, Emergency Assistance Temporary Housing & Human Services
Federal Emergency Management Agency

#7. Logistics
General Services Administration

#8. Public Health and Medical Services
Department of Health and Human Services

#9. Search and Rescue
Federal Emergency Management Agency

#10. Oil and Hazardous Materials
Environmental Protection Agency

#11. Agriculture & Natural Resources
Department of Agriculture

#12. Energy
Department of Energy

#13. Public Safety & Security
Department of Justice/Bureau of Alcohol, Tobacco, Firearms and Explosives

#14. Long-term Recovery and Mitigation*
***Replaced by National Disaster Recovery Framework**

#15. External Affairs
Department of Homeland Security

Recovery Support Functions (RSFs)

#1. Community Planning and Capacity Building
Federal Emergency Management Agency

#2. Economic
Department of Commerce

#3. Health and Social Services
Department of Health and Human Services

#4. Housing
Department of Housing and Urban Development

#5. Infrastructure and Systems
U.S. Army Corps of Engineers

#6. Natural and Cultural Resources
Department of Interior

Select HHS Response Resources

Support Local/State Public Health and Medical Services

- **National Disaster Medical System (NDMS)**
  Federally coordinated disaster healthcare system
  - Disaster Medical Assistance Teams DMAT
  - Disaster Mortuary Operational Response Team DMORT
  - National Veterinary Response Teams NVRT

- **Medical Reserve Corps (MRC)**
  National network of volunteer units
  - Support state and local response as requested
  - Support local health departments response to disasters in their communities

- **Strategic National Stockpile (SNS)**
  The Strategic National Stockpile contains Push Packages, which are:
  - Designed to protect the American public if local medical supplies run out.
  - Caches of pharmaceuticals, antidotes, and medical supplies.
  - Positioned in strategically located, secure warehouses for delivery within 12 hours.

- **US Public Health Service (USPHS)**
  Commissioned Corps
  - Rapid Deployment Force (RDF) Team
  - Mental Health Team

ASPR Health Care Readiness Programs Portfolio Overview

The ASPR Health Care Readiness Programs Portfolio is a suite of cooperative agreements that strengthen health care readiness at the local, state, and regional levels through collaboration among health care and public health entities.

PROGRAM	DESCRIPTION
Hospital Preparedness Program (HPP)	A cooperative agreement program that **prepares the health care system to save lives** during emergencies that exceed the day-to-day capacity of health care and emergency response systems. The recipients are health departments in all 50 states, territories, freely associated states, and DC, Chicago, LA County, and NYC.
Regional Disaster Health Response System (RDHRS)	A system that **builds partnerships to improve medical capacity, care coordination, and best practices** at a regional level. RDHRS has a vision of a full 12-site system to show the potential effectiveness and viability of a regionalized preparedness and response model.
Workforce Capacity	A program that **develops training and educational opportunities to improve health care readiness**; establishes guidance for workforce capacity programs.
National Special Pathogen System (NSPS)	A tiered, national system, established during COVID-19 pandemic, that **promotes, assesses and assists health care facility infectious disease readiness**, educates and trains providers, provides technical assistance, supports research, and enables planning and enacting surge activities.

Health and Social Services (HSS)

Core Recovery Mission Areas

- Public Health
- Health Care Services Impacts
- Behavioral Health Impacts
- Environmental Health Impacts
- Food Safety and Regulated Medical Products
- Long-term Health Issues Specific to Responders
- Social Services Impacts
- Referral to Social Services/Disaster Case Management
- School Impacts (Children in Disasters)

On the Web:
www.phe.gov

Facebook:
www.facebook.com/phegov

Twitter:
https://twitter.com/PHEgov

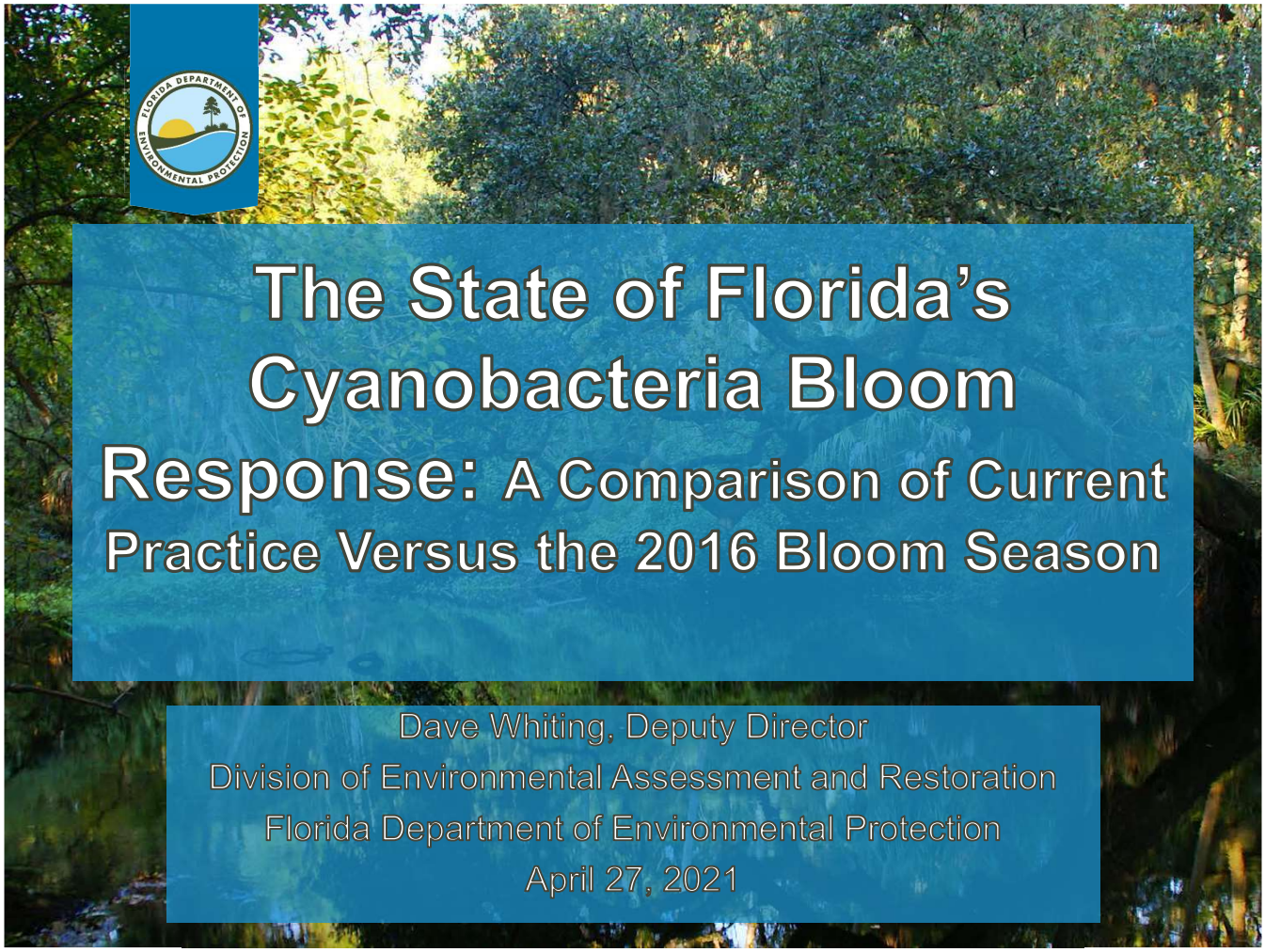
Instagram:
https://www.instagram.com/asprgov/

YouTube
https://www.youtube.com/user/PHEgov#

Linked In
https://www.linkedin.com/showcase/hhs-aspr/

Contact Us

Leremy Colf
Leremy.Colf@HHS.gov

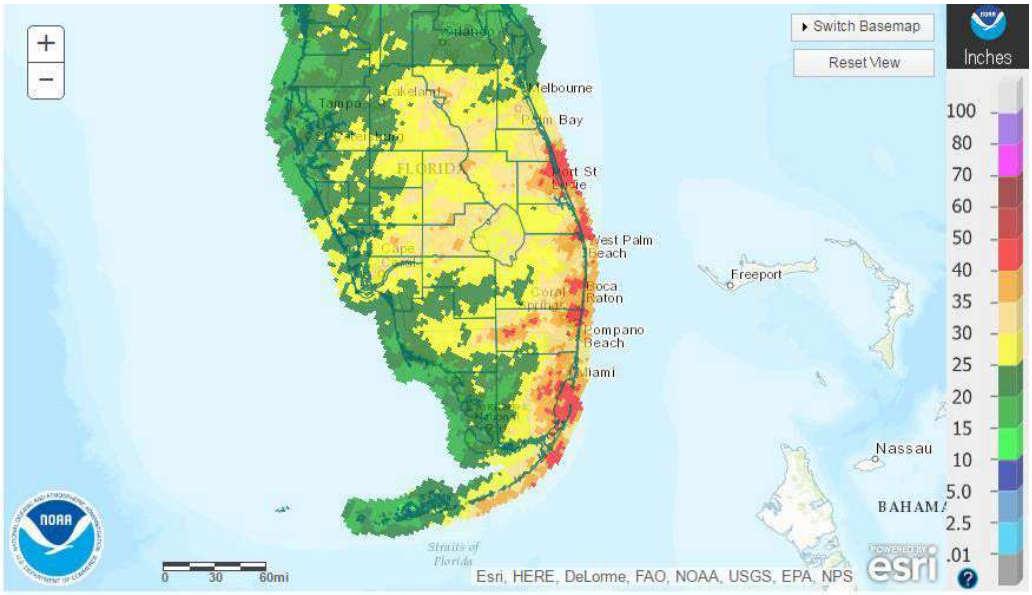


The State of Florida's Cyanobacteria Bloom Response: A Comparison of Current Practice Versus the 2016 Bloom Season

Dave Whiting, Deputy Director
Division of Environmental Assessment and Restoration
Florida Department of Environmental Protection
April 27, 2021

2016 Bloom Season

South Florida experienced a wetter than normal dry season (November – May) during 2015/2016, with the wettest winter on record for multiple cities

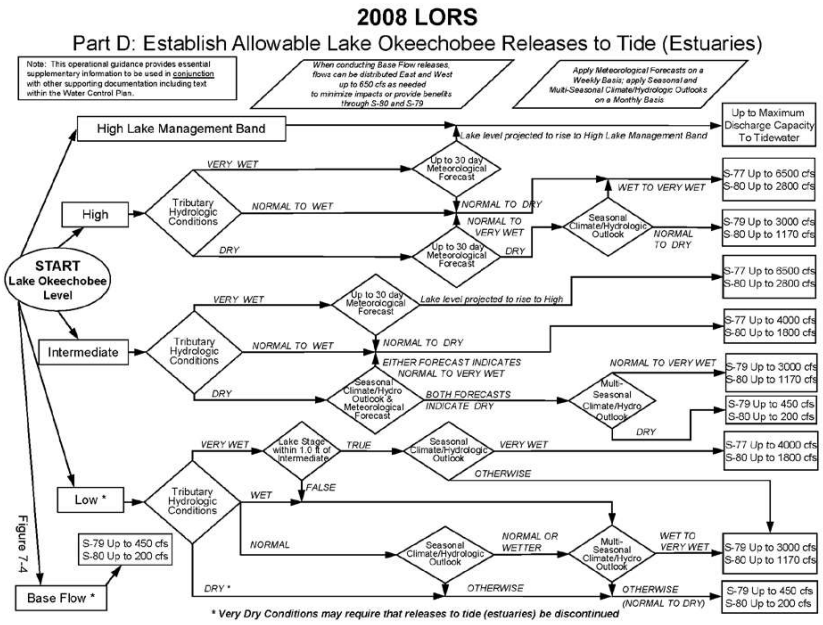


2016 Bloom Season

- The Florida Department of Environmental Protection (FDEP) was notified by the U. S. Army Corps of Engineers (USACE) about an algal bloom on Lake Okeechobee on May 13, 2016
- At the time, the National Oceanic and Atmospheric Administration (NOAA) was not providing daily 300-Meter resolution imagery of South Florida as they do now
- Lake Okeechobee is Florida's largest lake (730 square miles) that averages only 2.7 meters deep
- Lake Okeechobee is classified as a Class I potable drinking water source

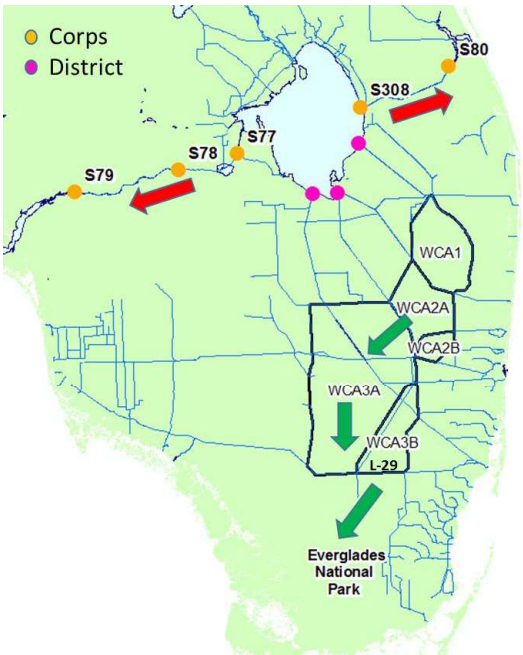
Lake Okeechobee Releases

- Due to concerns about the structural integrity of the Herbert Hoover Dike, the USACE must maintain the lake level according to a prescribed schedule



2016 Lake Okeechobee Releases

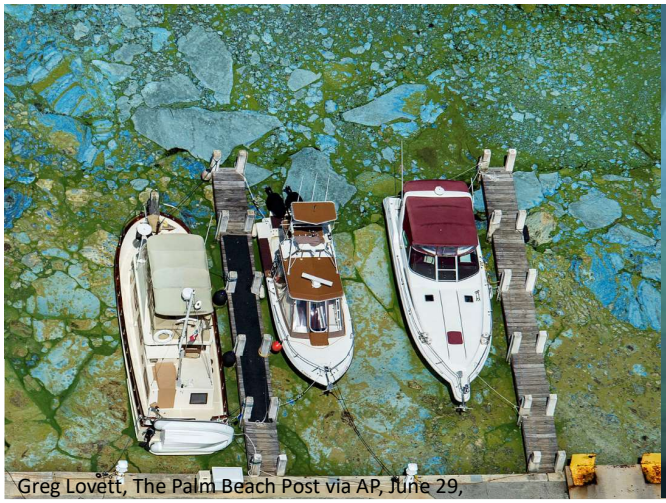
- Majority of the water is released to the Caloosahatchee and St. Lucie River systems, which lead to the Caloosahatchee and St. Lucie Estuary systems
- Past high volume releases have resulted in seagrass and shellfish die offs in the estuaries and contributed to significant algal blooms in these systems
- Smaller volumes of water are released to the south to the Water Conservation Areas



2016 Lake Okeechobee Releases

2016 Lake Okeechobee Releases

Large amounts of algal biomass were conveyed downriver, into dead end canals and marinas, and out into the Atlantic Ocean


Greg Lovett, The Palm Beach Post via AP, June 29,


Brian Ingram, June 26, 2016, Atlantic Ocean off St. Lucie Inlet

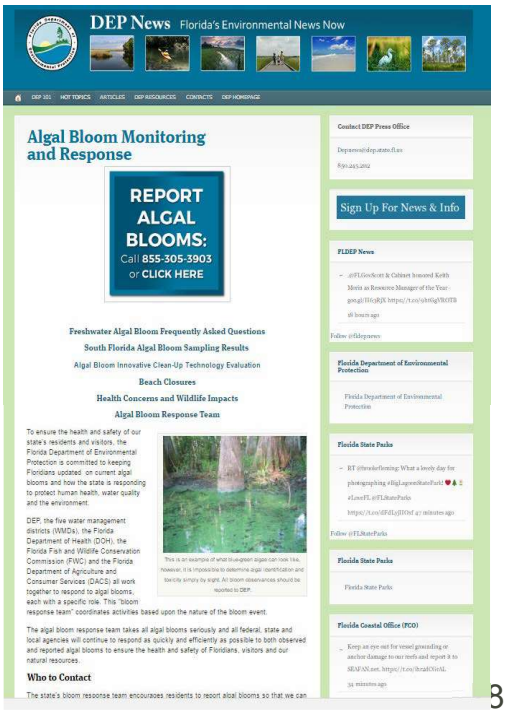
Current Lake Okeechobee Releases

- The USACE now has operational flexibility in how they implement their releases to help avoid large releases of bloom water
- Release non-bloom water in cooler winter/spring months to provide capacity to hold water during bloom season
- FDEP and USACE piloted innovative technologies at S308/ C77 discharge structures in 2020 to treat discharge water as needed.

Florida Department of Environmental Protection Outreach

Over the course of the 2016 bloom season, FDEP set up an algal bloom information page that provided:

- An algal bloom reporting hotline and webpage where citizens could report a bloom
- CyanoHAB FAQs
- Sampling results
- Information on innovative algal bloom clean-up technology evaluations
- Beach closure Information
- Human health and wildlife impact information
- Algal Bloom Response Team information



Florida Department of Environmental Protection Outreach

floridadep.gov/AlgalBloom

The current Algal Bloom Dashboard provides public access to large amounts of information and data.

Florida Department of Environmental Protection Outreach

floridadep.gov/AlgalBloom

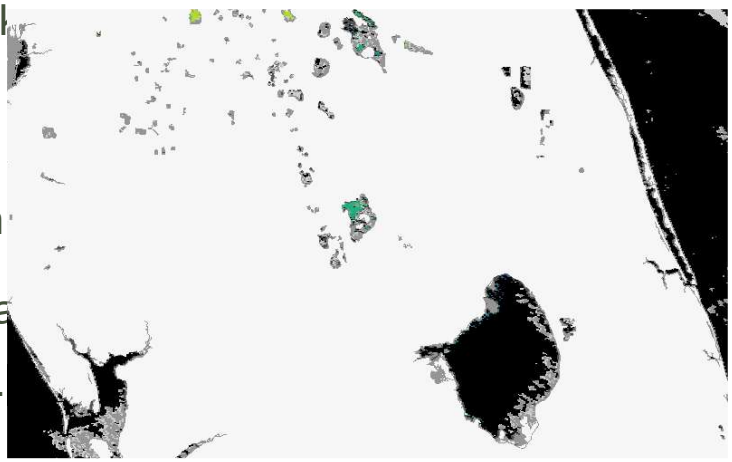
Florida Department of Environmental Protection Outreach

protectingfloridatogether.gov

FDEP has worked with the other state agencies to develop the Protecting Florida Together webpage which provides access to even more water quality, public health, and natural resource information

Currently Available NOAA Satellite Imagery

- FDEP was notified by the U. S. Army Corps of Engineers about an algal bloom on Lak Okeechobee on May 13, 2016
- At the time NOAA was not providing daily 300-Meter resolution imagery of South Florida at they do now
- Lake Okeechobee is Florida largest lake (730 square miles) that averages only 2. meters deep
- Lake Okeechobee is classified as a Class I potable drinking water source



2016 Algal Bloom Cleanup

- Previous cyanobacteria blooms had been self-resolving, without need for removal or treatment of algal biomass.
- There were no clean up contracts in place and companies began demonstrating their technologies without going through normal permitting review and approval

2016 Algal Bloom Cleanup

- FDEP, with the assistance of other federal and state agency staff, reviewed a wide range of cleanup/mitigation technologies
- Ultimately, FDEP set up contracts with two companies that local governments could piggyback on
  - Both companies use biomass removal and ozonation technologies

Blue Green Algae Task Force

- The Blue Green Algae Task Force (BGATF) was formed in 2019
- Produced consensus Document #1,October 11, 2019, which outlined recommendations by the BGATF

- Basin Management Action Plans
- Agriculture and Best Management Practices
- Human Waste
  - Onsite Sewage Treatment and Disposal Systems
  - Sanitary Sewer Overflows
- Stormwater Treatment
- Innovative Technologies
- Public Health
- Monitoring Needs

Blue Green Algae Task Force

Public Health

Defensible health advisories should be established by the Florida Department of Health and defensible water quality criteria should be established by the Florida Department of Environmental Protection. These actions should be supported by the best available science and monitoring, and updated as new information becomes available. The task force further recommends that the Department of Health work collaboratively with the Department of Environmental Protection to implement a transparent, consistent and comprehensive communication plan that recognizes the diverse population in Florida in order to inform the public about the potential health impacts associated with exposure to algae and/or algal toxins.

CyanoHAB Thresholds

The Precautionary Principle

- Florida Department of Health does not use a numeric toxin threshold value for HAB notifications
  - Presence/Absence of Cyanobacteria bloom or toxins
- Advise the public to avoid recreating and allowing pets or livestock in waters with visible algae present
- Cyanobacteria bloom conditions change rapidly
- Unable to sample, ship, analyze, and disseminate results rapidly enough to accurately inform the public about the risk of recreating in a water at the time of use
- Usually takes 3 – 4 days from sampling to posting of results

CyanoHAB Thresholds

How much is too much?

- EPA's 2018 and World Health Organizations 2020 recommended cyanotoxin thresholds are ***based solely on incidental ingestion*** by children during normal recreational activity (i.e., swimming pool study) and **only use toxicological data for MC-LR**
- Do not account for any other exposure routes (i.e., inhalation, dermal, fish/shellfish consumption)
- FDEP is not adopting EPA's recommended cyanotoxin criteria during this Triennial Review of its Water Quality Criteria

CyanoHAB Thresholds

- EPA recommended Criteria

Table 6-1. Recreational Criteria or Swimming Advisory Recommendations for Microcystins and Cylindrospermopsin[a]

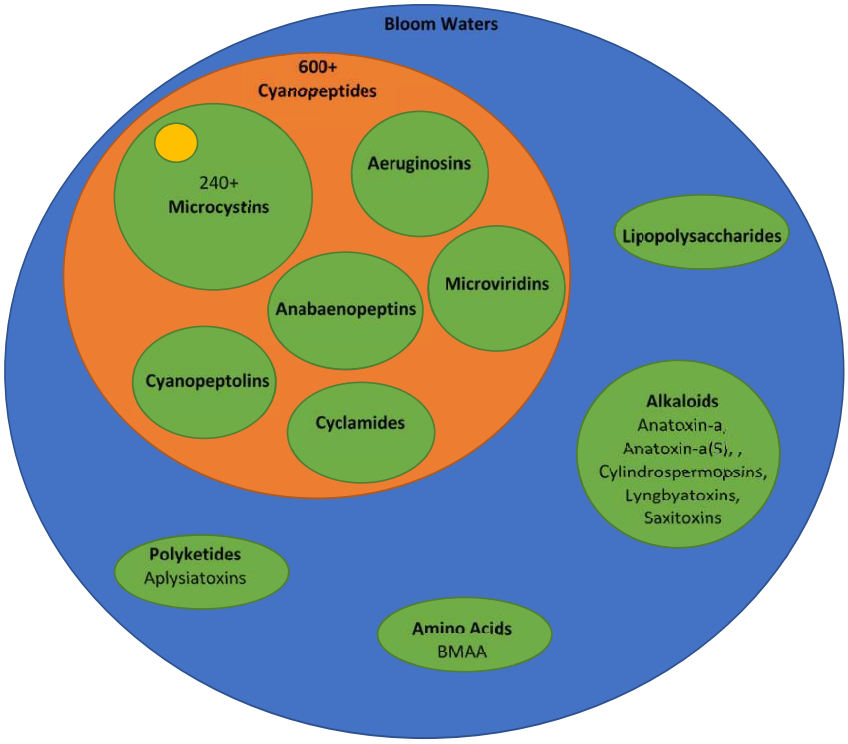
Application of Recommended Values	Microcystins			Cylindrospermopsin		
	Magnitude (µg/L)	Duration	Frequency	Magnitude (µg/L)	Duration	Frequency
Recreational Water Quality Criteria	8	1 in 10-day assessment period across a recreational season	More than 3 excursions in a recreational season, not to be exceeded in more than one year[b]	15	1 in 10-day assessment period across a recreational season	More than 3 excursions in a recreational season, not to be exceeded in more than one year[b]
Swimming Advisory		One day	Not to be exceeded		One day	Not to be exceeded

- World Health Organization thresholds

Calculation of provisional recreational water GV for MC-LR: = NOAEL ∗ bw UF ∗ C = 40 ∗ 15 100 ∗ 0.25 µg/L = 24 µg/L

where GVrecreation = guideline value for recreational exposure NOAEL = no-observed-adverse-effect level (40 µg/kg bw/day, based on Fawell et al., 1999) bw = body weight (default = 15 kg for a child) UF = uncertainty factor (100 = 10 for interspecies variation × 10 for intraspecies variation) C = daily incidental water consumption (default = 250 mL for a child)

Cyanotoxins



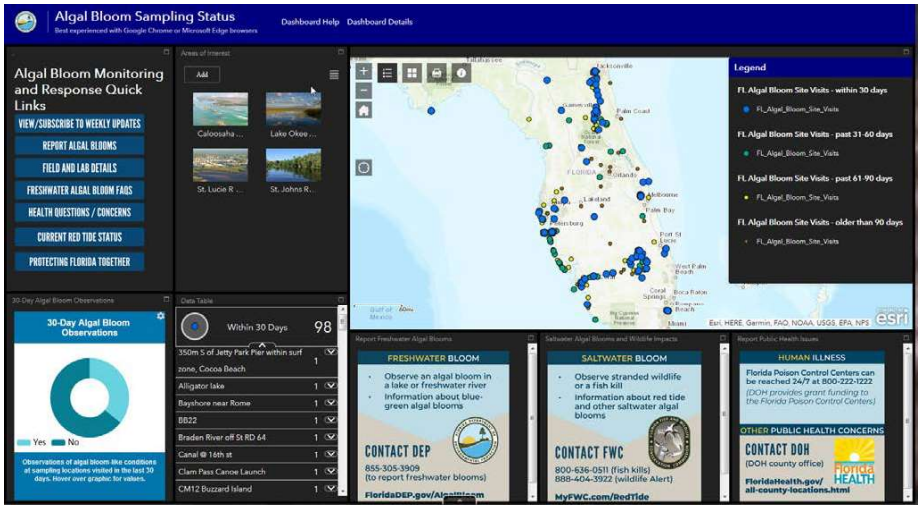
CyanoHAB Sampling

What gets analyzed?

- Cyanotoxins
  - Microcystins (LR, RR, YR, LA, LF, LY, LW, WR, desmethyl LR, HilR and HtyR)
  - Anatoxin-a
  - Cylindrospermopsin
  - Saxitoxins (in some waters)
- Algal Identification
- Chlorophyll *a*
- Nutrients

What happens with the Results?

- Results are posted to the DEP Algal Bloom Dashboard
- DOH reviews daily and contacts local county health departments



DOH CyanoHAB Notifications

- Caution sign used when cyanobacteria present but toxins not detected
- Health Alert sign used when cyanotoxins detected

DOH CyanoHAB Notifications

- Daily email from DOH regarding cyanobacteria results includes a table to help local health departments with decisions regarding the need for signage

DOH Blue-Green Algae Daily Update for Florida February 19, 2021
Listings below based on information downloaded 2/19/2021 7:40:51 AM

County	Sites with Bloom Present	Sites with Toxins Detected	Follow-up Sample Found No Toxins	Pending Toxin Results	No Longer Pending No Toxins Detected	Point Map Photo
Brevard	-	-	-	Lake Washington - Center (LWC)	Lake Washington - Center (LWC)	Point Map Photo
Leon	-	-	-	-	Lake Bradford - Western Shore	Point Map Photo
Okeechobee	-	-	-	Lake Okeechobee - LZ2	-	Point Map No Photo
Orange	-	Lake Conway @ SW Shore	-	-	-	Point Map Photo
Orange	-	Lake Holden 90m S of Lake Holden Point	-	-	-	Point Map Photo
Orange	-	Lake Anderson - NW Corner	-	-	-	Point Map No Photo
Pinellas	-	-	-	-	Round Lake	Point Map Photo
Putnam	-	-	-	Crescent Lake-mouth of Dunns Creek (CRESLM)	-	Point Map No Photo
Putnam	-	-	-	Crescent Lake - mouth of Dunns Creek (CRESLM)	-	Point Map No Photo
Volusia	-	-	-	Lake George - Center (LEO)	Lake George - Center (LEO)	Point Map No Photo

Summary

- Florida has greatly improved its freshwater HAB response coordination, capabilities, and outreach since 2016
- The USACE has greater flexibility to avoid large releases of bloom water from Lake Okeechobee
- Innovative technologies will likely be used in any future release to reduce environmental and human health impacts
- The FDOH uses the presence of potential toxin-producing cyanobacteria and detection of any level of cyanotoxins as health notification thresholds
- The FDEP will not be adopting EPA's recommended cyanotoxin thresholds for recreational waters, but will explore adopting more scientifically defensible criteria in the future

2018 FLORIDA RED TIDE CASE STUDY: SCIENTIFIC AND COMMUNICATION RESPONSE

Dr. Kate Hubbard

Florida Fish and Wildlife Conservation Commission-Fish and Wildlife Research Institute

9/17/2018; 2:45PM; 8MI SW OF SIESTA KEY (27.214299° , -82.667561°) PHOTO CREDIT: ALEX DESMIDT, FWC AERIAL SURVEY

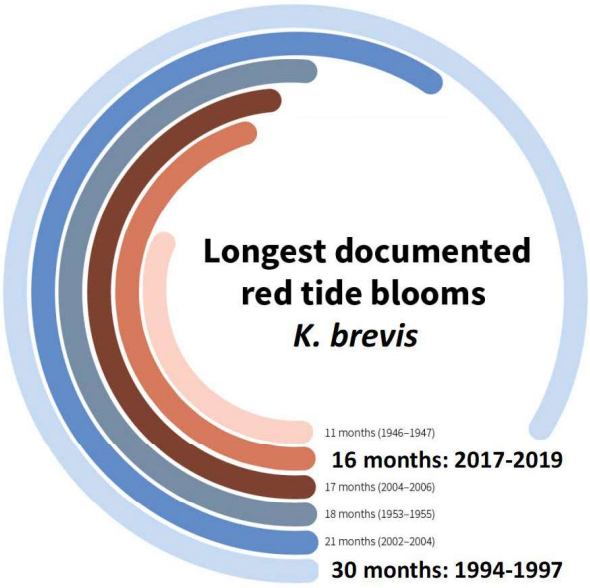
What is Red Tide?

- Caused by toxic microscopic marine alga, *Karenia brevis*
- Shellfish (clams, oysters, mussels) feed on toxic cells, accumulate toxin, and can cause Neurotoxic Shellfish Poisoning (NSP) in humans
- Toxin is aerosolized in sea spray and causes respiratory irritation
- Produces toxins that kills wildlife
- Economic impact relative to tourism and clean up costs associated with fish kills on beaches

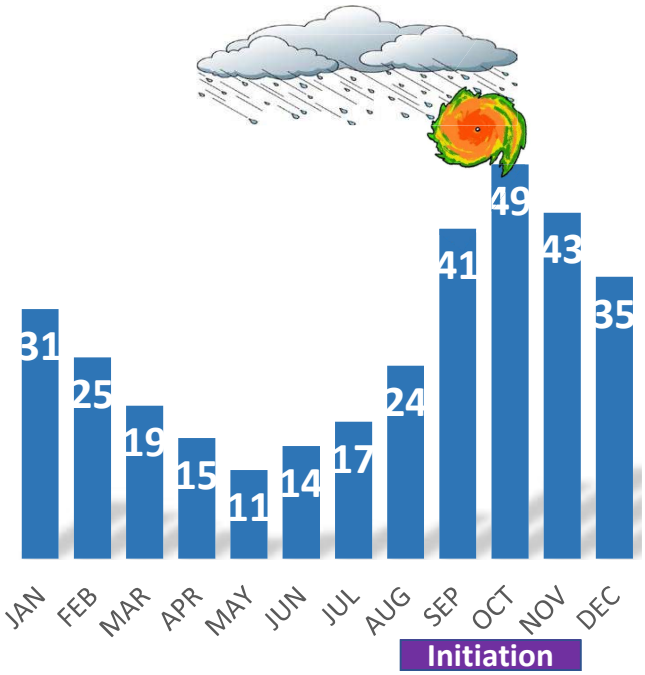
RED TIDE OCCURS REGULARLY IN THE GULF OF MEXICO

- Blooms in SW FL were first identified in the 1840's
- Red Tide occurs nearly every year off SW FL
- SW FL blooms can be transported south and occasionally to the Atlantic
- Sometimes Florida's blooms are carried west and can impact other Gulf states
- Red tide also occurs along the Mexico/Texas coast

# of years with blooms (≥100,000 cells/L) since 1953 (69 years)

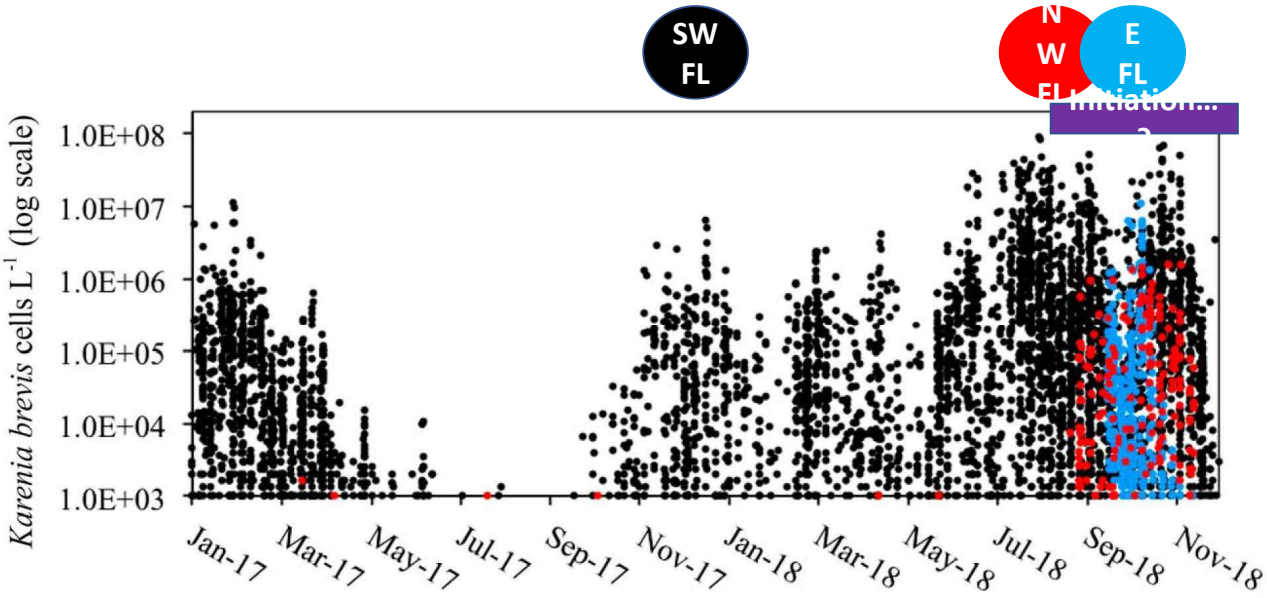


BLOOM THRESHOLD : 100,000 cells L^{-1}



# of years with a documented bloom by month, 1953-2019

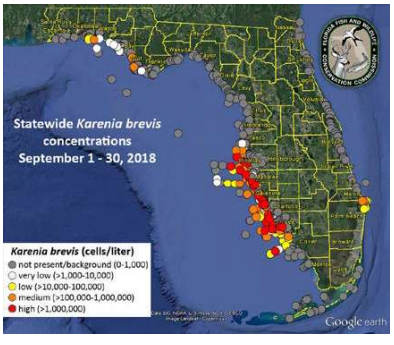
THE 16 MONTH BLOOM: NOVEMBER 2017 TO FEBRUARY 2019



WEISBERG ET AL. 2019

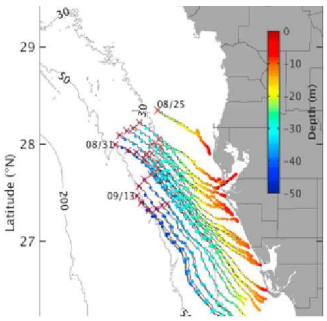

18,294,466 cells/L
51,063,420 cells/L
Redington Beach 9/17/18


Statewide Karenia brevis
concentrations
August 1 - 31, 2018
Karenia brevis (cells/liter)
not present/background (0-1,000)
very low (>1,000-10,000)
low (>10,000-100,000)
medium (>100,000-1,000,000)
high (>1,000,000)
Google earth


Statewide Karenia brevis
concentrations
September 1 - 30, 2018
Karenia brevis (cells/liter)
not present/background (0-1,000)
very low (>1,000-10,000)
low (>10,000-100,000)
medium (>100,000-1,000,000)
high (>1,000,000)
Google earth


Statewide Karenia brevis
concentrations
October 1 - 31, 2018
Karenia brevis (cells/liter)
not present/background (0-1,000)
very low (>1,000-10,000)
low (>10,000-100,000)
medium (>100,000-1,000,000)
high (>1,000,000)
Google earth

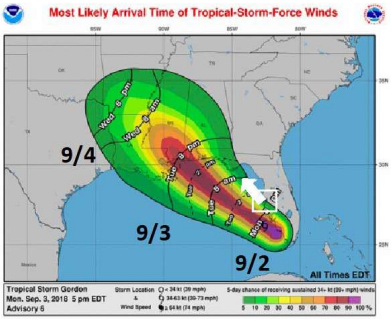
West Florida Coastal Ocean Model



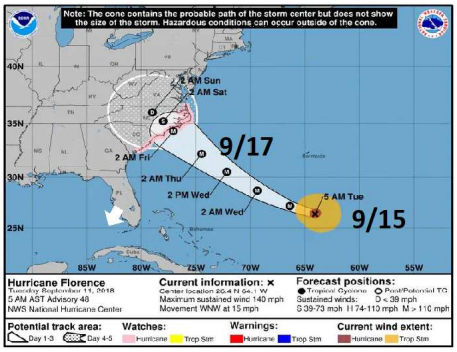
Near bottom Lagrangian trajectories

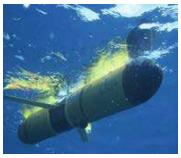
WEISBERG ET AL. 2019

Tropical Storm Gordon

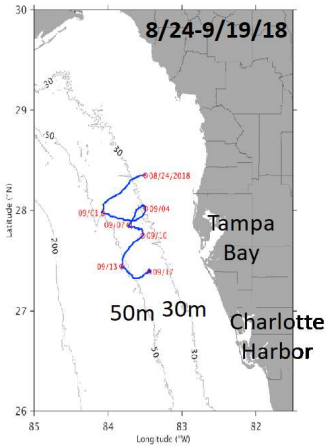


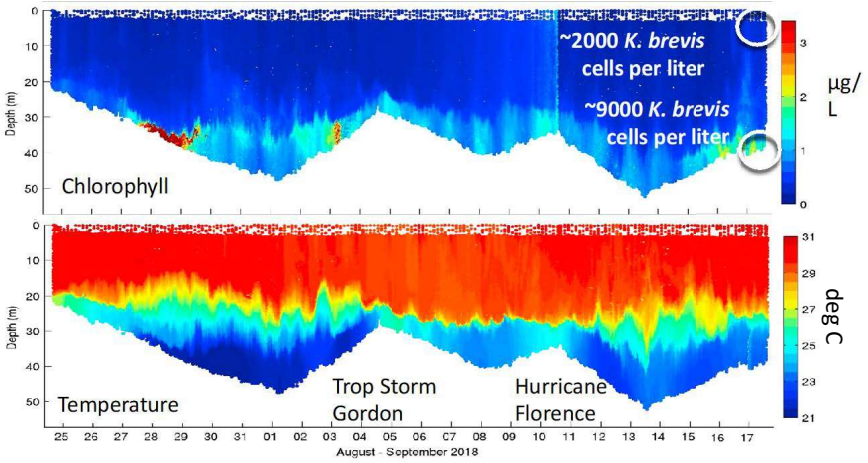
Hurricane Florence





Gliders helped map subsurface "initiation zone"

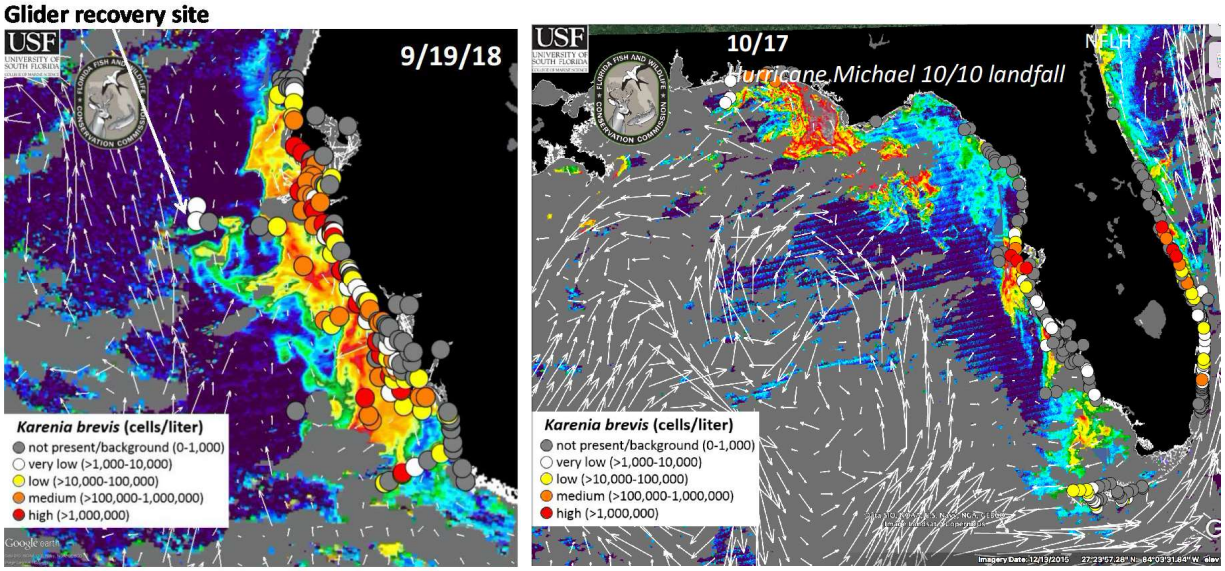




http://gandalf.gcoos.org/

https://www.marine.usf.edu/COT/

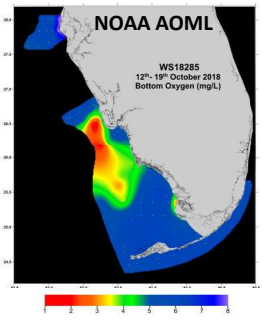
Sea Surface Chlorophyll (NFLH)

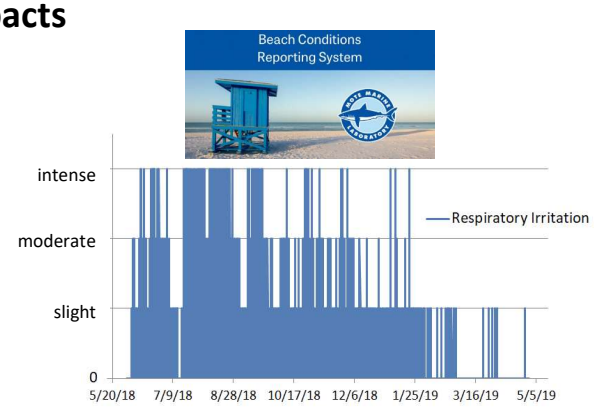


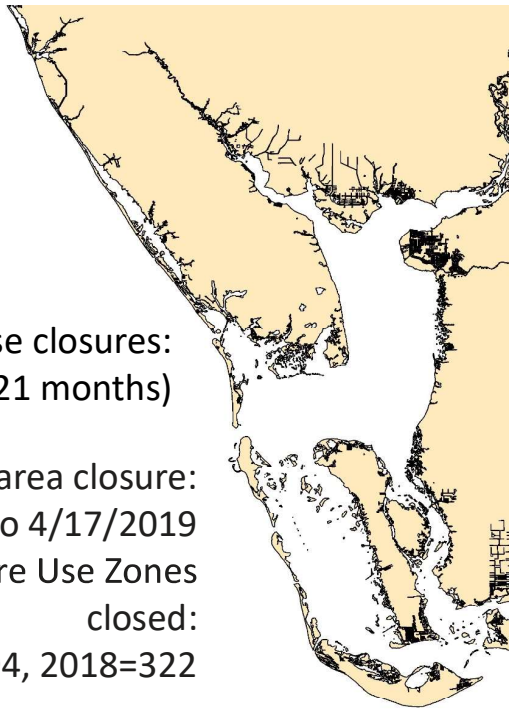
USF Ocean Optics Group

https://optics.marine.usf.edu

Impacts





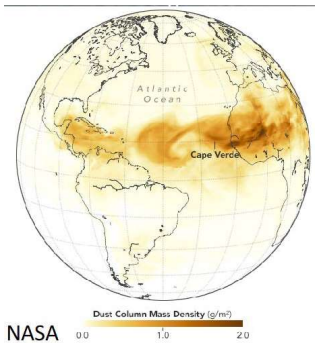


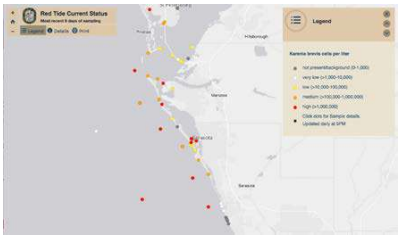
Gasparilla Sound area and lease closures:
11/14/2017- 7/4/2019 (21 months)

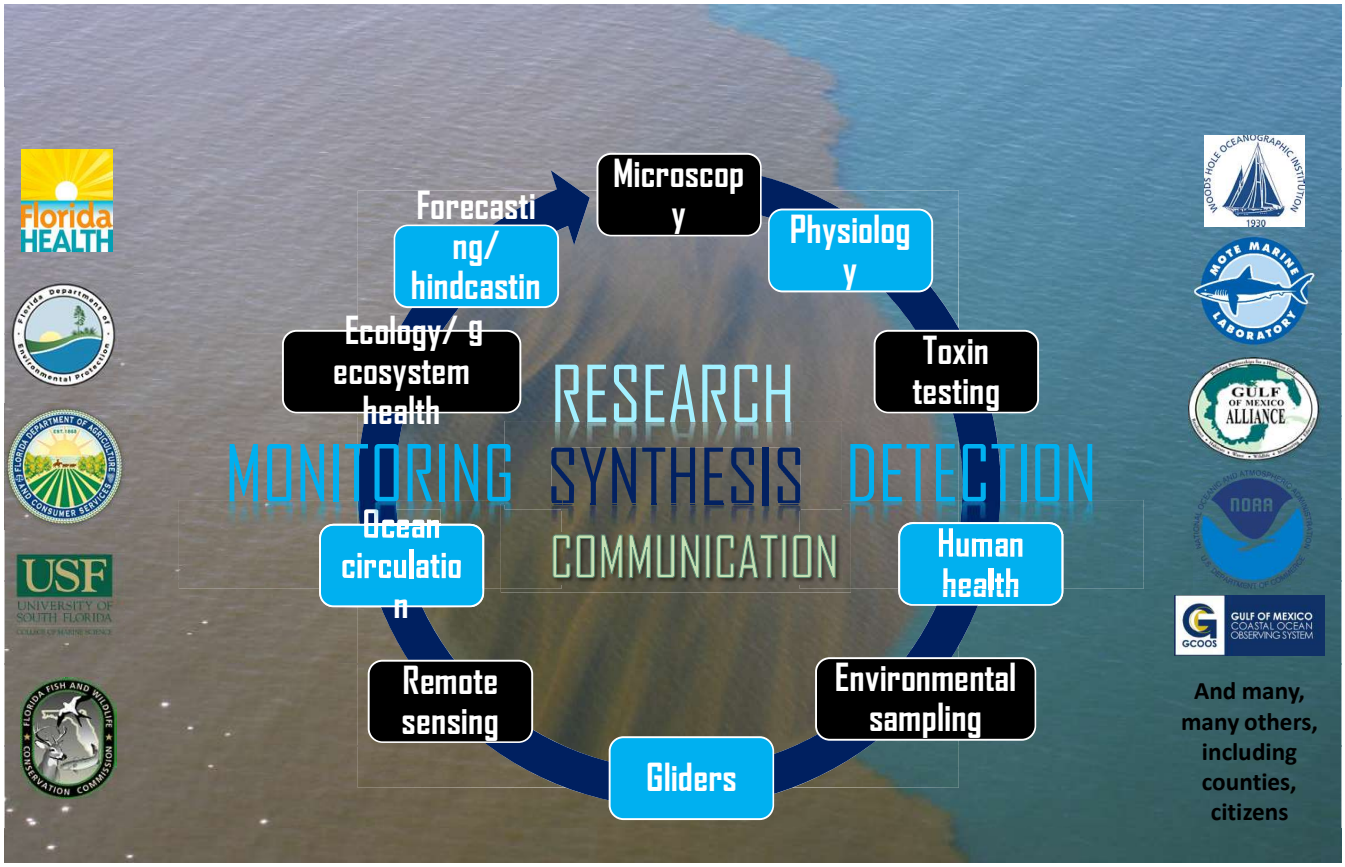
Charlotte Harbor area closure:
11/14/2017 to 4/17/2019
Pine Island Aquaculture Use Zones closed:
total days: 2017=94, 2018=322

Communication during with 2017-2019 bloom:
Thousands of requests for information (media/public)
Multiple high profile blooms
Bloom during election
Rampant misinformation
General skepticism
Federal/state jurisdiction
Didn't have tools/resources/data to address all the questions at the right time

Solutions:
(1) Share what we do know and update as we know more; (2) share what we don't know; (3) describe paths to get there





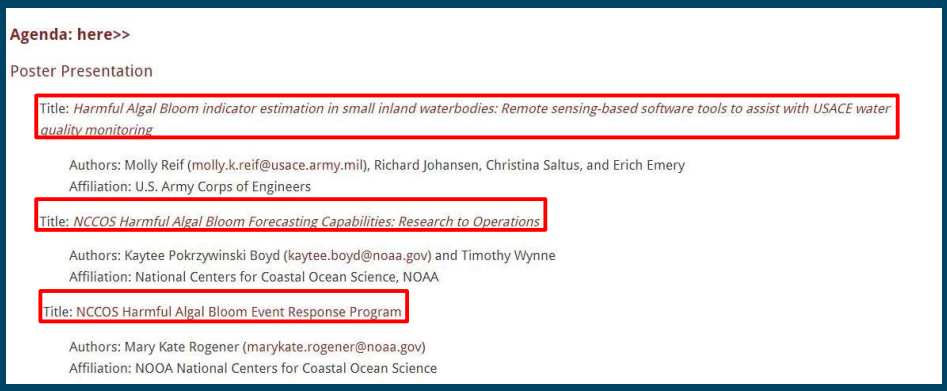

Microscopy
Physiology
Toxin testing
Human health
Environmental sampling
Gliders
Remote sensing
Ocean circulation
Ecology/ ecosystem health
Forecasting/ hindcasting
RESEARCH
MONITORING
SYNTHESIS
DETECTION
COMMUNICATION
And many, many others, including counties, citizens


Harmful Algal Bloom (HAB)
Preparedness & Response
Workshop
April 27 - 28, 2021
1:00 – 4:00 PM (EDT)

Wrap Up

POSTER PRESENTATIONS

Step 1: Go to website (https://crrc.unh.edu/workshop/HAB)
Step 2: Scroll to "Poster Presentation" section
Step 3: Click on the poster links



Agenda: here>>

Poster Presentation

Title: *Harmful Algal Bloom indicator estimation in small inland waterbodies: Remote sensing-based software tools to assist with USACE water quality monitoring*

Authors: Molly Reif (molly.k.reif@usace.army.mil), Richard Johansen, Christina Saltus, and Erich Emery
Affiliation: U.S. Army Corps of Engineers

Title: *NCCOS Harmful Algal Bloom Forecasting Capabilities: Research to Operations*

Authors: Kaytee Pokrzywinski Boyd (kaytee.boyd@noaa.gov) and Timothy Wynne
Affiliation: National Centers for Coastal Ocean Science, NOAA

Title: NCCOS Harmful Algal Bloom Event Response Program

Authors: Mary Kate Rogener (marykate.rogener@noaa.gov)
Affiliation: NOOA National Centers for Coastal Ocean Science

THANK YOU FOR LISTENING

https://crrc.unh.edu/workshop/HAB

Next Session: Wednesday, April 28
1:00 - 4:30 pm ET

Harmful Algal Bloom Preparedness & Response

Nancy E. Kinner, Facilitator
Coastal Response Research Center (CRRC)
University of New Hampshire

April 28, 2021

HOW TO PARTICIPATE

- Software will be Zoom (federal employees do not have to download the client, access through browser)
- Submit questions or comments via the Q&A option
  - Questions will be monitored and collated
  - Facilitator will announce questions
  - Some answers may be available via the Q&A option
- If you have any access issues, please contact Kathy at kathy.mandsager@unh.edu or cell 603.498.8010

HAB PREPAREDNESS & RESPONSE: WORKSHOP GOAL

To better understand:

1. The roles and responsibilities of different Federal HAB response agencies
2. The science and tools that help drive decision-making
3. The importance of inter-agency coordination

STEERING COMMITTEE

Charles Grisafi, NOAA
Katie Krushinski, NOAA
Tony Marshak, NOAA
Jennifer Graham, USGS
Lesley D'Anglada, USEPA
Tesfaye Bayleygen, CDC
Tony Clyde, USACE
Tony Hill, USACE
Charlie Henry, NOAA
Christine Tomlinson, USEPA
Lorraine Backer, CDC
Stacey Wiggins, FDA
Joselito Ignacio, FEMA
Mary Kate Rogener, NOAA
Nancy Kinner, CRRC
Katie Perry, CRRC

Coastal Response Research Center

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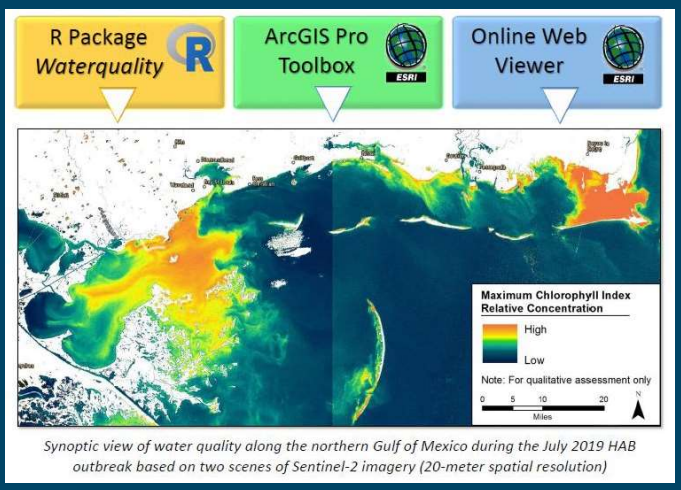
POSTER PRESENTATIONS

Harmful Algal Bloom indicator estimation in small inland waterbodies: Remote sensing-based software tools to assist with USACE water quality monitoring



Synoptic view of water quality along the northern Gulf of Mexico during the July 2019 HAB outbreak based on two scenes of Sentinel-2 imagery (20-meter spatial resolution)

Authors: Molly Reif, Richard Johansen, Christina Saltus, and Erich Emery

U.S. Army Corps of Engineers

Coastal Response Research Center

POSTER PRESENTATIONS

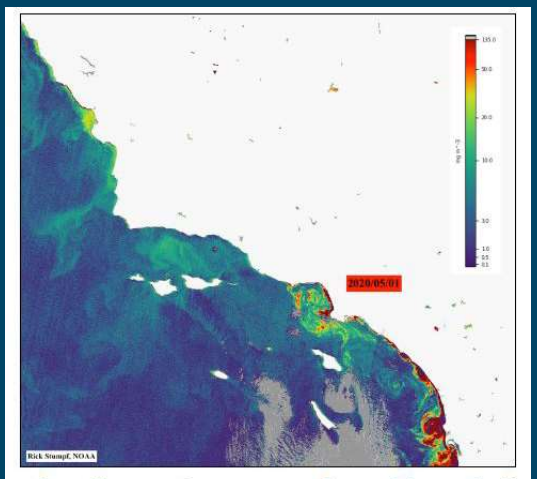
NCCOS Harmful Algal Bloom Forecasting Capabilities: Research to Operations

Authors: Kaytee Pokrzywinski Boyd, Timothy Wynne

National Centers for Coastal Ocean Science, NOAA

POSTER PRESENTATIONS

NCCOS Harmful Algal Bloom Event Response Program



Satellite Image of chlorophyll concentration showing the extent of a bloom off the coast of Southern California, May 2020. Credit NOAA

Authors: Mary Kate Rogener

NOAA National Centers for Costal Ocean Science

HOW TO PARTICIPATE

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  - **Questions will be monitored and collated**
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THANK YOU FOR LISTENING

https://crrc.unh.edu/workshop/HAB

Coastal Response Research Center

Risk & Crisis Communication

HAB Preparedness & Response Workshop

April 28, 2021

About Me

Katie Krushinski

Emergency Management Specialist

NOAA OR&R, Disaster Preparedness Program (DPP)

Contact Info

Email: katherine.krushinski@noaa.gov

Phone: (251) 234-1734 – cell

Experience

- **Springfield-Greene County OEM** – *Continuity of Operations Coordinator*
- **NOAA Disaster Response Center (Genwest Systems)** – *Exercise & Communication Coordinator*
- **NOAA –** *Emergency Management Specialist*

Education

Bachelor of Science, Professional Writing

Missouri State University

Master of Science, Emergency Management

Jacksonville State University

Professional Certifications

- ***Certified Emergency Manager (CEM)*** – *IAEM*
- ***Master Exercise Practitioner (MEP)*** – *FEMA*
- ***Professional Continuity Practitioner (PCP)*** – *FEMA*

Risk Defined

A threat of loss, real or perceived, to that which we value.

(Covello & Milligan, 2012)

Risk = Hazard x Consequence

What is a Disaster?

- Deadly, destructive, and disruptive events that occur when a hazard (or multiple hazards) interact(s) with human vulnerability. (McEntire, 2007)
- An event that produces greater losses then a community can handle, including casualties, property damage, and significant environmental damage. (Lindell, Prater, & Perry, 2007)
- Sudden-onset occasions that seriously disrupt social routines, cause adoption of unplanned actions to adjust to the disruption, are designated in social space and time, and that endanger valued social objects. (Perry & Lindell, 2007)

What is a Crisis

- A specific, unexpected, and non-routine event or series of events that create high levels of uncertainty and threaten or are perceived to threaten an organization's (or person's) high priority goals. (Sellnow & Ulmer, 2009)

Levels of Crisis

Characteristics	Emergencies	Disasters	Catastrophes
Impacts	Impacts localized	Impacts widespread, severe	Extremely large physical & social impacts
Geographic Extent	Mainly local	Multi-jurisdictional, intergovernmental, bottom up approach	Requires federal initiative, proactive mobilization
Pre-incident Planning	Standard operating procedures used	Disaster plans put into effect – but challenges remain	Massive challenges exceed those envisioned in pre-existing plans
Response Resources	Vast majority of response resources are unaffected	Extensive damage to, disruption of, key emergency services	Emergency response system paralyzed at local and event state levels
Public Involvement	Not generally involved in response	Extensively involved in response	Extensively involved in response, with long-term mass convergence
Recovery	No significant recover challenges	Major recovery challenges	Cascading long-term effects, with massive recovery challenges

(Tierney, 2009)

Communication

17

Risk Communications

A science-based approach for communicating effectively in a:

- High concern environment
- Low trust
- Sensitive topic
- Controversial situation

Goals of Risk Communication

Increase Knowledge & Understanding

- Clear, concise, and science-based info
- Know your audience and target your message

Enhance Trust

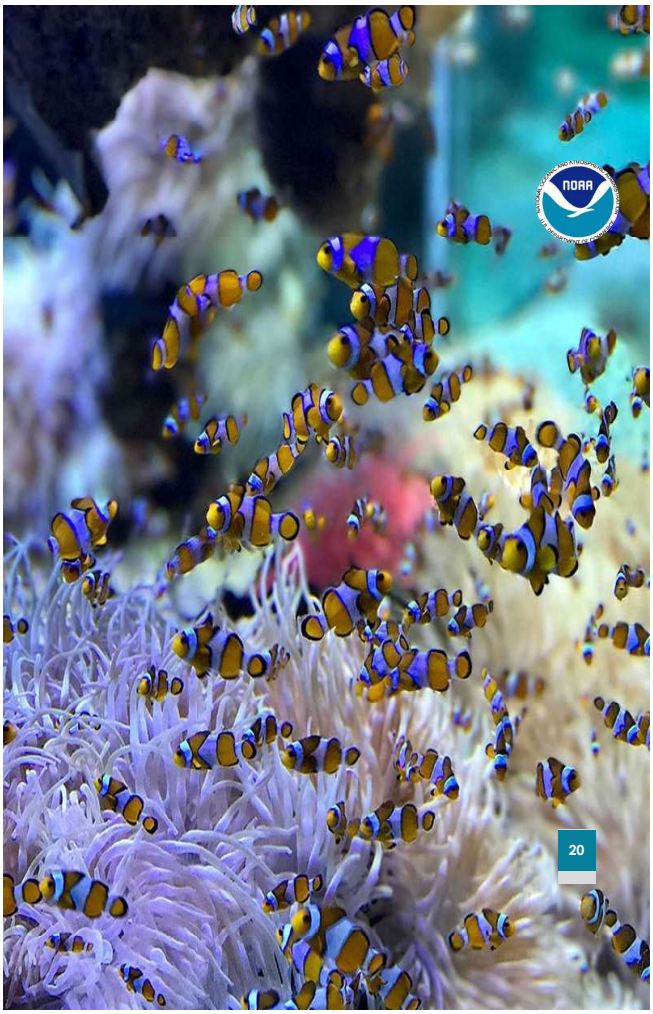
- Ensures your audience "hears" your message(s)
- Help to improve people's actions and heed warnings

Resolve Conflict

- Acknowledge and resolve quickly
- Helps to promote knowledge and understanding while building trust

Crisis Communications

The exchange of risk-relevant and safety information during an emergency situation. (Sellnow, Ulmer, Seeger, & Littlefield, 2009)



Risk vs Crisis Communications

Risk Communications

- Exchange of information about the nature of the risk and risk management options
- Essential to manage potential risks
- Effective communication:
  - Take into account audience's existing beliefs, including perceptions about risk
  - Address audience's decision/judgements (opinions)

What MIGHT happen

Crisis Communications

- More message driven
- Use media to influence public beliefs, opinions, and judgments
  - Regain control of the situation and conversation
  - Minimize impact on operations and target audiences
  - Minimize time spent on crisis
- Rapid response communications from external/public affairs

What HAS happened

Perception

Past Experiences

Many people compare disasters and their impacts to create their perception of the current situation.

"My family hasn't left for a hurricane in 50 years!"

Socioeconomic Factors

Factors such as employment, education, and income influence people's perception.

If people don't have the resources to repair and/or rebuild, their perception of the risk changes.

Availability of Information

Getting the right message to the right people at the right time is key to determining one's level of risk.

Be aware of your community's populations.

Build Trust: Empathy & Honesty

Do

- Acknowledge uncertainty
- Establish your own humanity
- Acknowledge errors, deficiencies, misbehaviors
- Apologize early & often
- Be careful of comparisons

Don't

- Over-reassure
- Aim for zero fear
- Lie or tell half truths
- Ridicule the public's emotions

Build Trust: Dedication & Expertise

Do

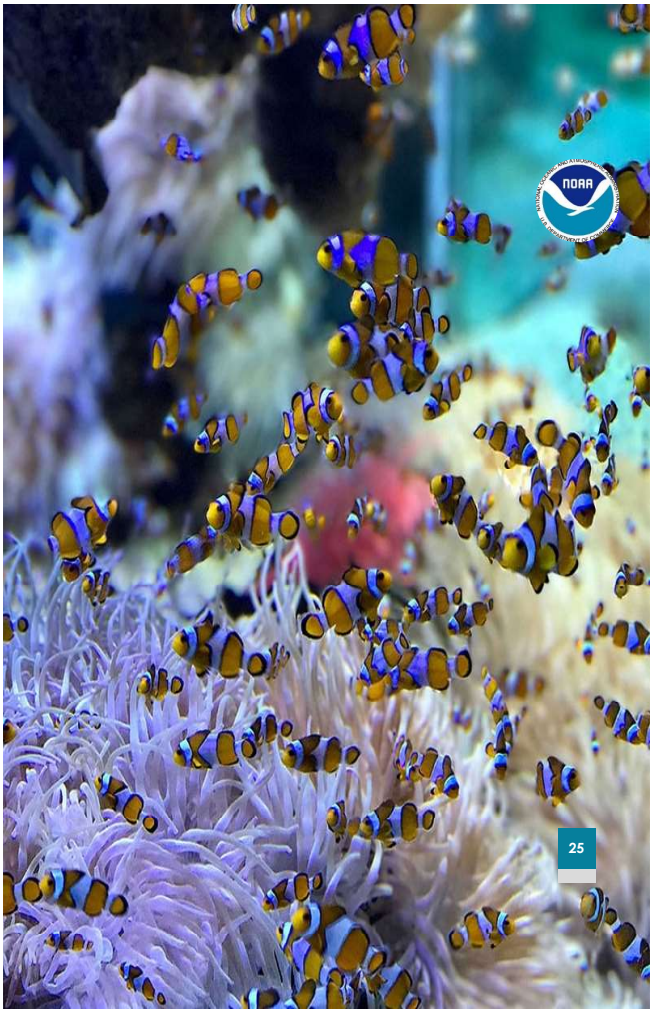
- Prepare at least 3 times more facts/figures
- Be organized
- Dress appropriately
- Be concise, clear, & brief
- Develop key messages specific to your stakeholders
- Use active listening

Don't

- Use technical jargon
- Use lots of notes
- Avoid written speeches
- Ignore audience's non-verbal queues

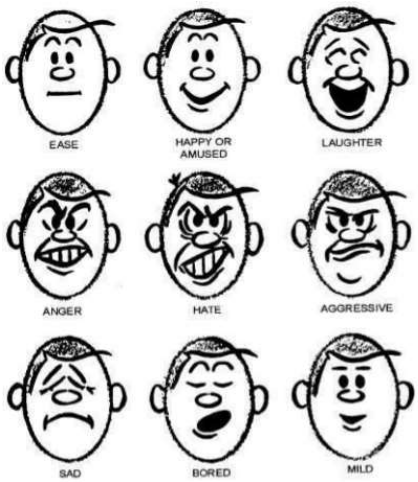
Communicating Through Social Media

- Understand the level of effort and time commitment
- Strategically choose social media platforms
- Share your message on multiple platforms
- Be sure to share science-based information
- Leverage your audience's networks



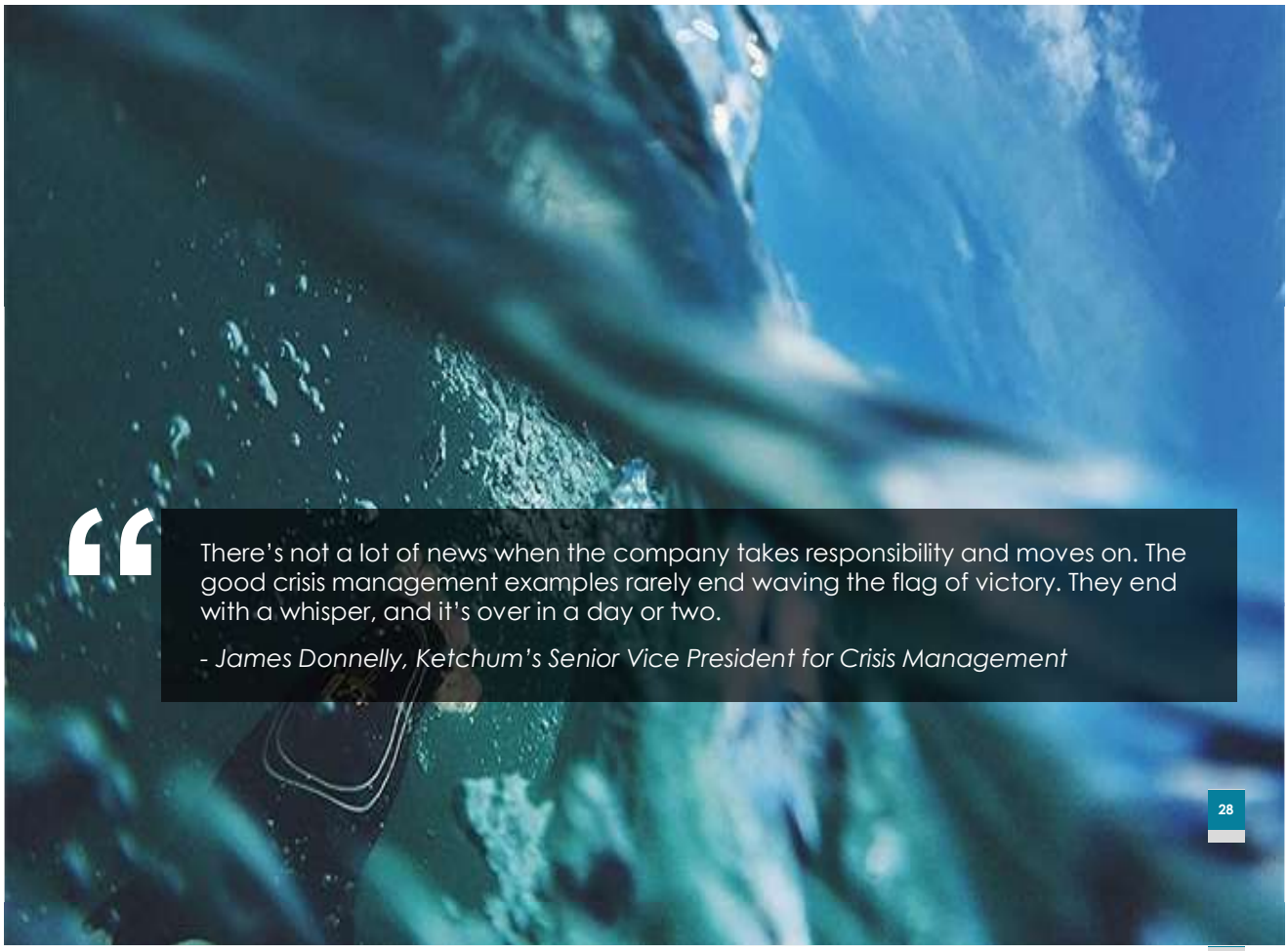
Non-Verbal Communication

- Provides 2/3 of your messages content
- Noticed immediately by audience
- Interpreted negatively
- Over-rides verbal communication

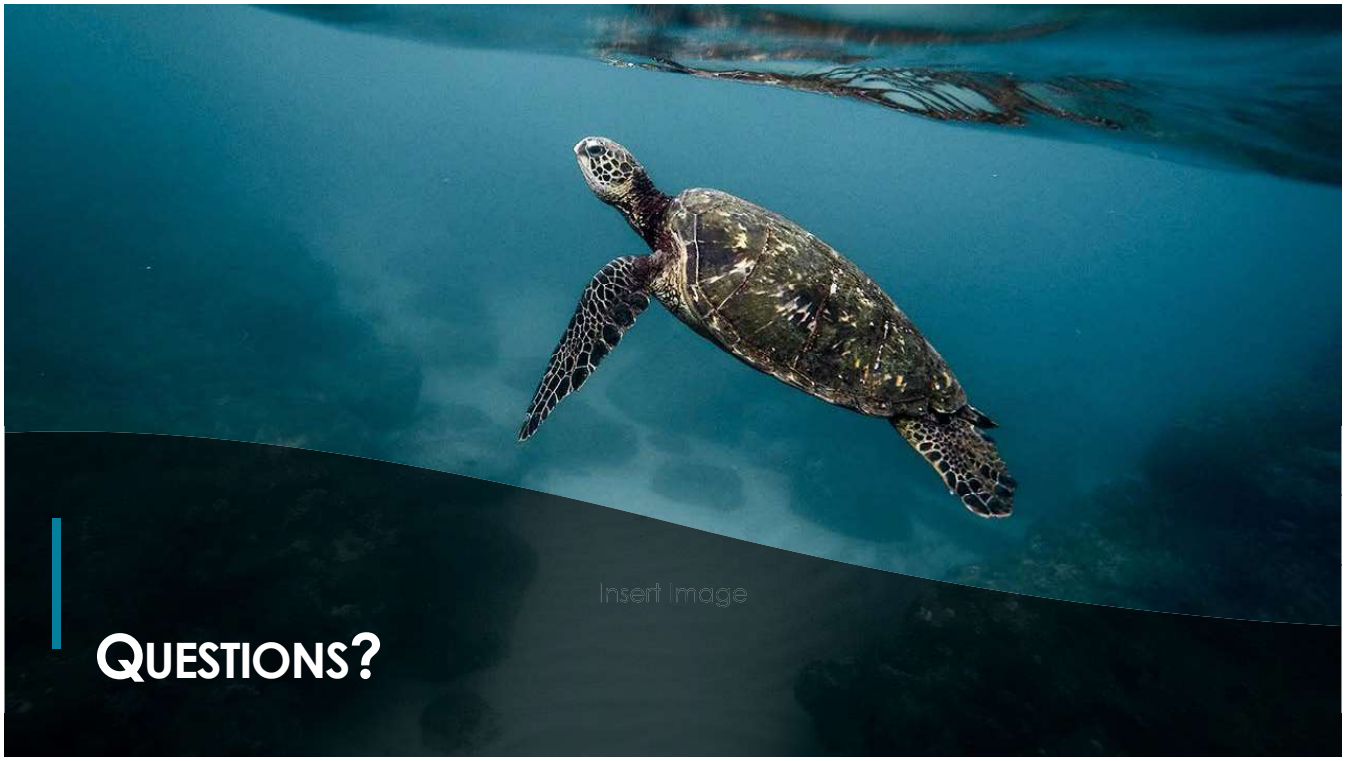


Final Thoughts

- *Know your audience*
- *Make a plan*
- *Communicate early and often*



> There's not a lot of news when the company takes responsibility and moves on. The good crisis management examples rarely end waving the flag of victory. They end with a whisper, and it's over in a day or two.
>
> *- James Donnelly, Ketchum's Senior Vice President for Crisis Management*



QUESTIONS?

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United States Environmental Protection Agency

Risk Communication Before, During and After a Freshwater CyanoHABs

Dr. Lesley V. D'Anglada
Office of Science and Technology
Office of Water
U.S. EPA

Harmful Algal Bloom Preparedness and Response Workshop

April 27 and 28, 2021

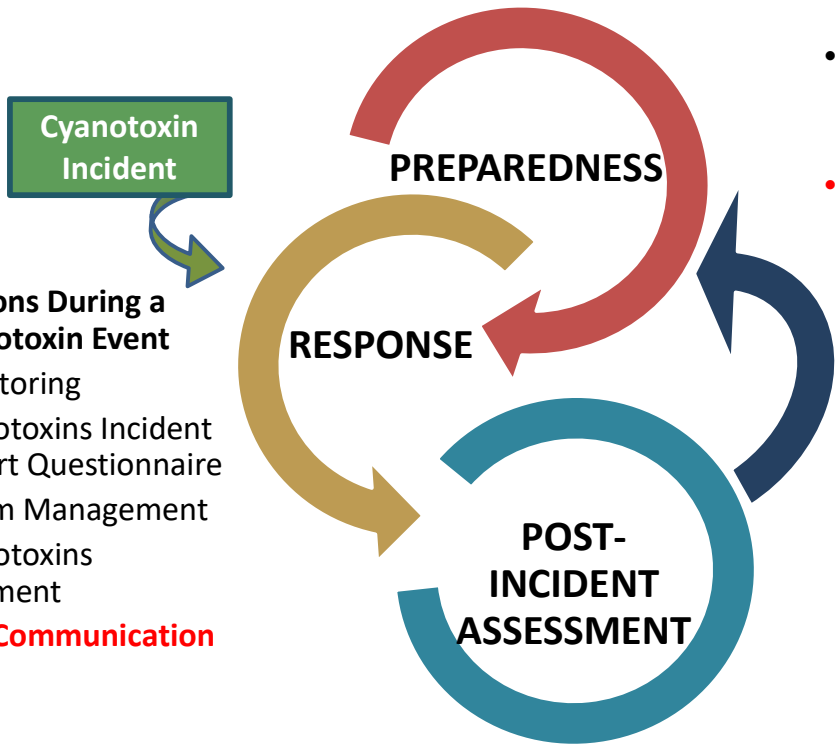
Nex
t

Presentation Overview

- Overview of the US EPA risk communications tools to use before, during and after a cyanoHABs and cyanotoxins events in drinking and recreational waters.

Disclaimer

The views expressed in this presentation are those of the author and do not necessarily represent the views or policies of the U.S. Environmental Protection Agency.



Actions Prior to a Cyanotoxin Event

- Incident Response and Communication Team
- **Cyanotoxins Management Plan (CMP)**

Actions During a Cyanotoxin Event

- Monitoring
- Cyanotoxins Incident Report Questionnaire
- Bloom Management
- Cyanotoxins Treatment
- **Risk Communication**

Actions After a Cyanotoxin Event

- Post-Event Review Questionnaire
- CMP Revision
- **Risk Communication**

Preparedness

Risk Communication Actions PRIOR to a Cyanotoxins Event

Before a HABs event, it is recommended to:

- Public water systems as well as recreational water managers with source waters that are susceptible to HABs can benefit from developing a **Cyanotoxin Management Plan.**
- Preparing for a HABs event also involves establishing communication plans for the public. Water managers and public water systems can also benefit from developing a **Risk Communication Plans**.
- Surface water utilities can use a **HABs Incident Action Checklist** to prepare for, respond to and recover from HABs incidents.

Risk Communication Tools to Prepare For Cyanotoxins Events

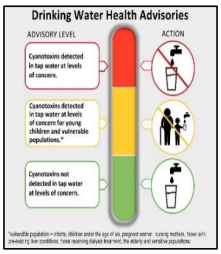
- ✓ EPA's Cyanotoxin Management Plan Template and Example Plans
- ✓ Drinking Water Cyanotoxin Communication Toolbox
- ✓ Recreational Water Communication Risk Toolbox for Cyanobacterial Blooms
- ✓ EPA HABs Incident Action Checklist

Response

Risk Communication Actions DURING a Cyanotoxins Event

During a suspected or confirmed cyanotoxins event, it is recommended to:

- Have accessible **Frequently Asked Questions** on cyanobacteria and cyanotoxins for risk communication with public and media.
- Have accessible ready-to-use **templates** to develop risk communication materials.
- Have accessible tools for water managers and public water systems to **monitor and respond to** cyanobacteria and their toxins.



Risk Communication Tools to Assist During a Cyanotoxins Incident

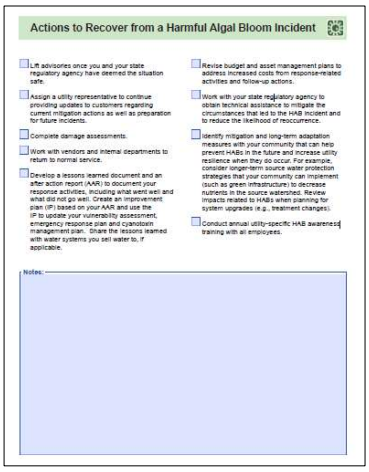
- ✓ Harmful Algal Blooms and Cyanotoxins FAQs
- ✓ Frequently Asked Questions: Laboratory Analysis for Microcystins in Drinking Water
- ✓ Monitoring and Responding to Cyanobacteria and Cyanotoxins in Recreational Water
- ✓ Recommendations for Public Water Systems to Manage Cyanotoxins in Drinking Water
- ✓ Water Treatment Optimization for Cyanotoxins

Post-Incident Assessment

Risk Communication Actions AFTER a Cyanotoxins Event

Once the HABs and cyanotoxins event is over, it is recommended to:

- Conduct a **post-incident comprehensive assessment** to identify the adequacy of the cyanotoxins incident response and assess the effectiveness of the response.
- **Debrief** with the all the involved agencies, e.g. drinking water systems and managers of recreational sites, after the incident to identify problems during the incident and determine areas that need improvement, as well as those actions that contributed to a successful response and that should be repeated in future cyanotoxins contamination events.

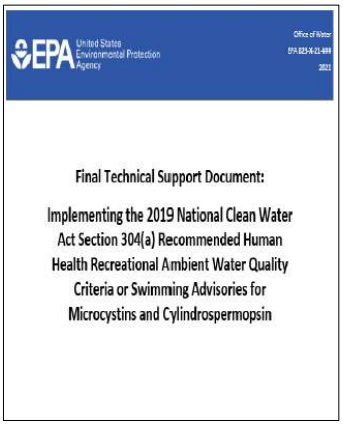


Risk Communication Resources to use after a cyanotoxins event

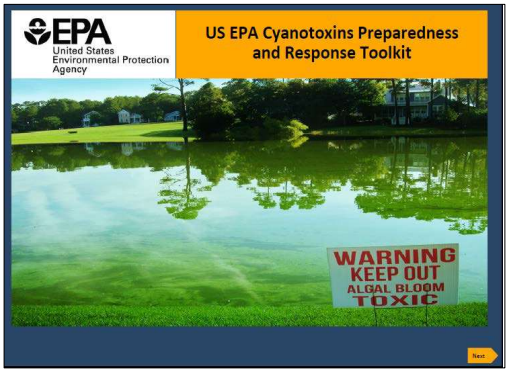
- ✓ Incident Action Checklist - Harmful Algal Blooms

Coming Soon

Two more tools coming very soon…



- General Questions about Recommended Cyanotoxin Water Quality Criteria
- Implementation Questions about Monitoring, Assessment and Listing
- Implementation Questions about Water Quality Management Plans



- Tool with resources to prepare for, respond to and respond to cyanotoxins in drinking and recreational waters.
- Provides templates, questionnaires, worksheets, and checklists to be completed electronically, save, download or share.

Contact Information

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EPA's CyanoHABs in Water Bodies Website
www.epa.gov/cyanohabs

Jonathan Lynch, MBA-PM

- Career background
  - Deputy Associate Director for Communication, CDC's Division of Environmental Health Science and Practice
  - 2011–2020: Health communication specialist for multiple CDC emergency activations
  - 2003–2011: Editor for *Epi-X*
  - 1993–2003: Producer in CNN Medical Unit
  - 1991–1993: Production assistant for CDC Special Assignment

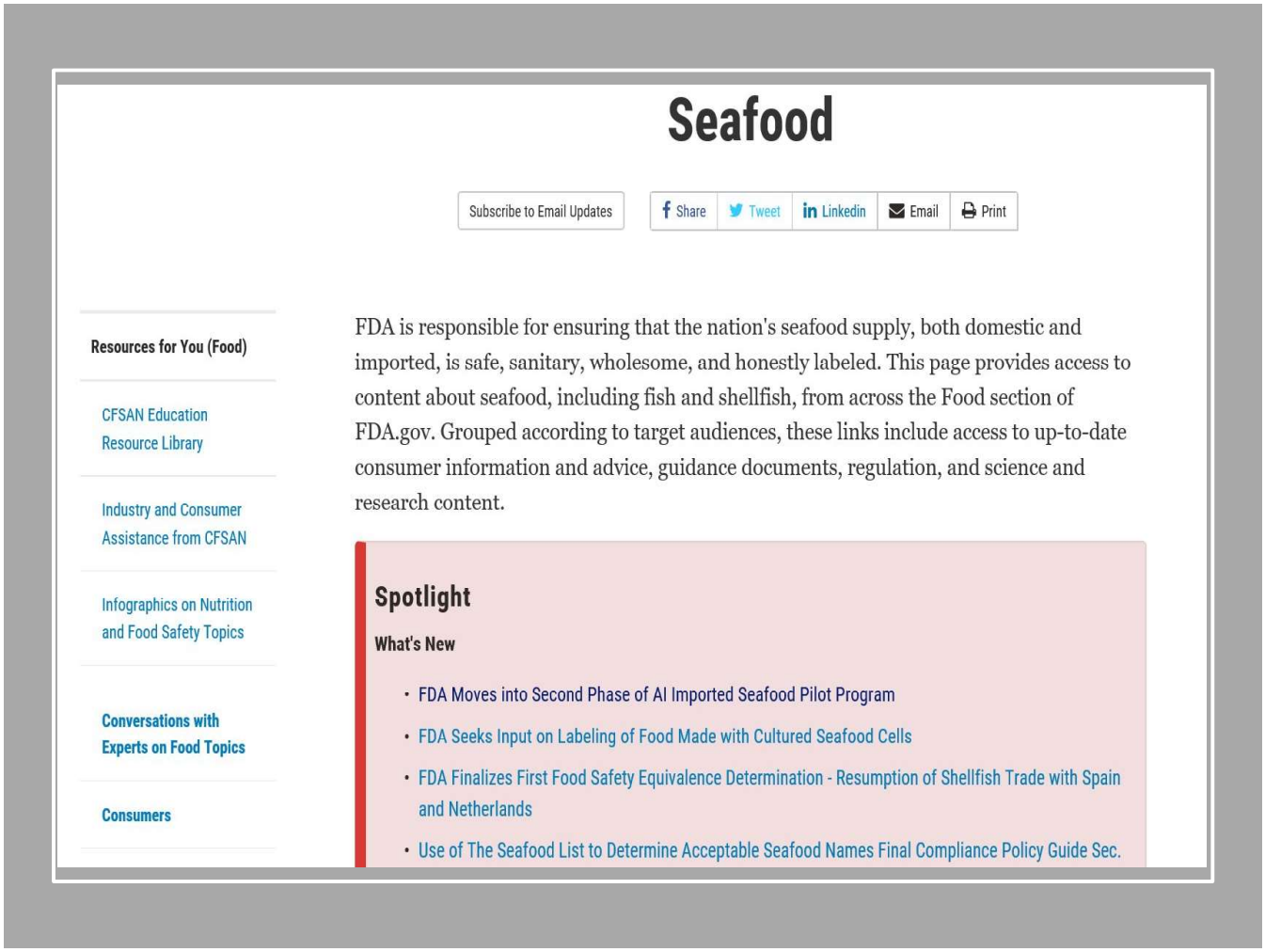
Jonathan Lynch, MBA-PM (continued)

- Career focus
  - Emergency response communications
  - Project management
  - Partnership building
  - Planning communication campaigns
  - Writing and editing
  - Webinars
  - Software development with LiveCode

Stacey Wiggins, Ph.D.
Division of Seafood Safety/Office of Food Safety
Center for Food Safety & Applied Nutrition
Food & Drug Administration

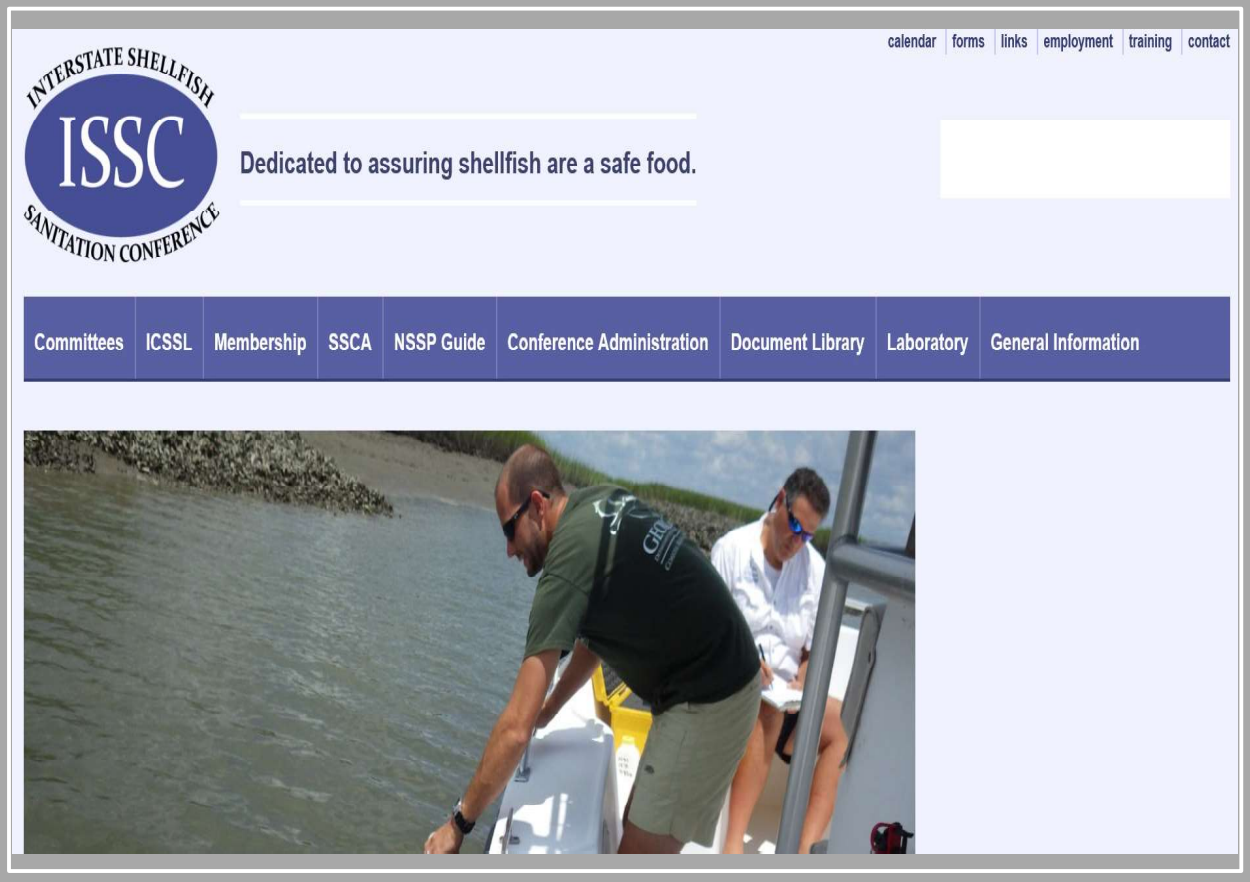
HAB COMMUNICATIONS

FDA RESOURCES FOR MOLLUSCAN SHELLFISH



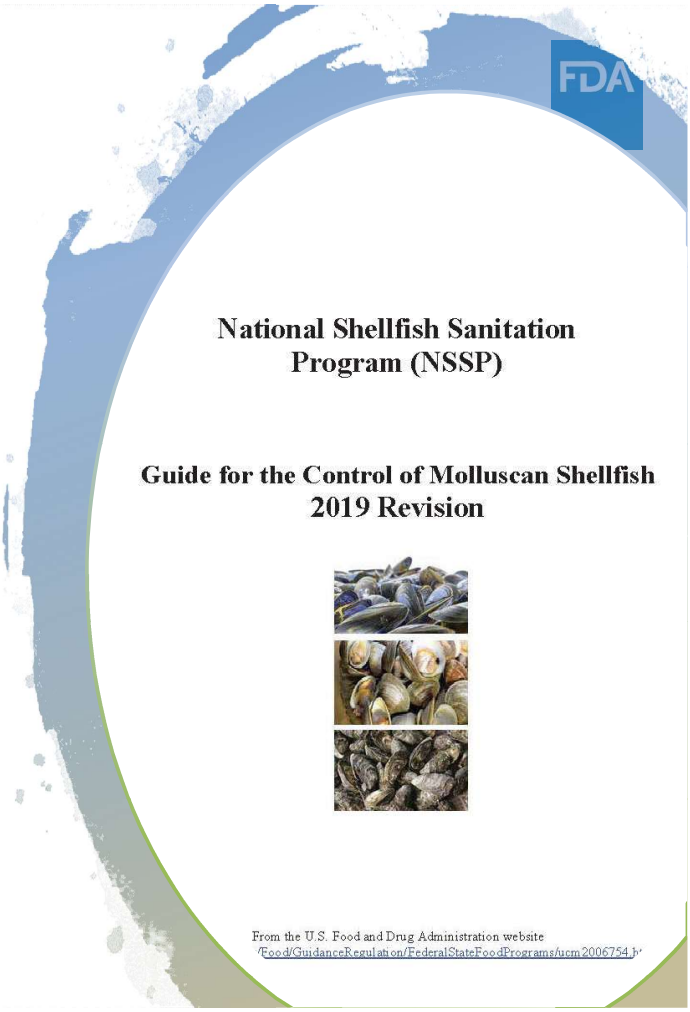
FDA Webpage Resources

- Training video on marine biotoxin management
- National Shellfish Sanitation Program
- Bad Bug Book



ISSC Webpage Resources

- New & Notices
  - Illnesses/Outbreaks
  - Shellfish Closures
  - Reopenings
  - Recalls
- Laboratory
  - Domestic Laboratory List
  - Method Validation
- NSSP Guide
  - Marine Biotoxin Control
  - Laboratory Methods



Communication Challenges with Public Health Response to HABs

Challenges:

- Multilingual Audience
- English as Second Language
- Cultural Preferences
- Economic Disincentives
- Vacationer Access
- Science deficits and “deniers”
- HAB Fatigue

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Principal Scientist
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NOAA Harmful Algal Bloom (HAB) Preparedness and Response Workshop 4/27-28/2021

Dan Ayres, Coastal Shellfish Fishery Manger
Washington Department of Fish and Wildlife


TRINITY
CAUTION
USE HANDRAILS
SLIPPERY WHEN WET

State of Washington
Department of Fish and Wildlife

48 Devonshire Road, Montesano, Washington 98563-9618 (360) 249-4628 FAX (360) 249-1229

June 5, 2015

Contact: Dan Ayres 360-249-4628 (ext. 209)

WASHINGTON COASTAL DUNGNESS CRAB INDUSTRY NOTICE

IMMEDIATE CLOSURE

Effective immediately, WDFW is implementing the following change to coastal commercial Dungeness crab regulations:

The coastal waters between the Washington/Oregon border (46°15.00) and Point Chehalis (46°53.18), including the Columbia River and Willapa Bay are CLOSED to the harvest and possession of Dungeness crab.

This action is a result of increasing levels of domoic acid in recent Dungeness crab samples. These levels now exceed the closure criteria established by the Washington Department of Health.

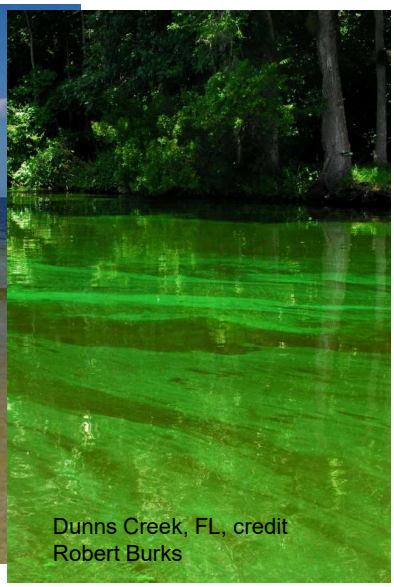
- **Successful Tools**
  - **Email** distribution lists
  - No-reply **TEXT** system (commercial fishers)
  - **Web** site / MUST BE KEPT UPDATED
    - Graphics showing toxin trends
    - Maps showing closed areas
  - **Social** Media
    - Twitter and Facebook (need to be monitored)

- **Communication with the Public**
  - Messaging needs to consider both under-concerned people and the overly concerned people.
  - Keep it simple, but some compelling language may be necessary…*"at high levels domoic acid can cause stroke-like symptoms or death"*
  - We do what we can to avoid last minute closures. Improved forecast ability is important.

- **Communication with Industry**
  - With a lot of $$ on the line, be transparent and avoid alarmist language.
  - Keep the science as simple as possible.
    - avoid using jargon
    - avoid streams of facts
    - don't get bogged down in the details
    - stick with one set of terms without interchanging (*HAB, harmful algae, plankton, diatoms, pseudo-nitzschia, toxin, domoic acid*)

Lacey Goeres-Priest
Water Quality Supervisor
City of Salem | Public Works Department

Remote Sensing of Harmful Algal Blooms, marine and freshwater

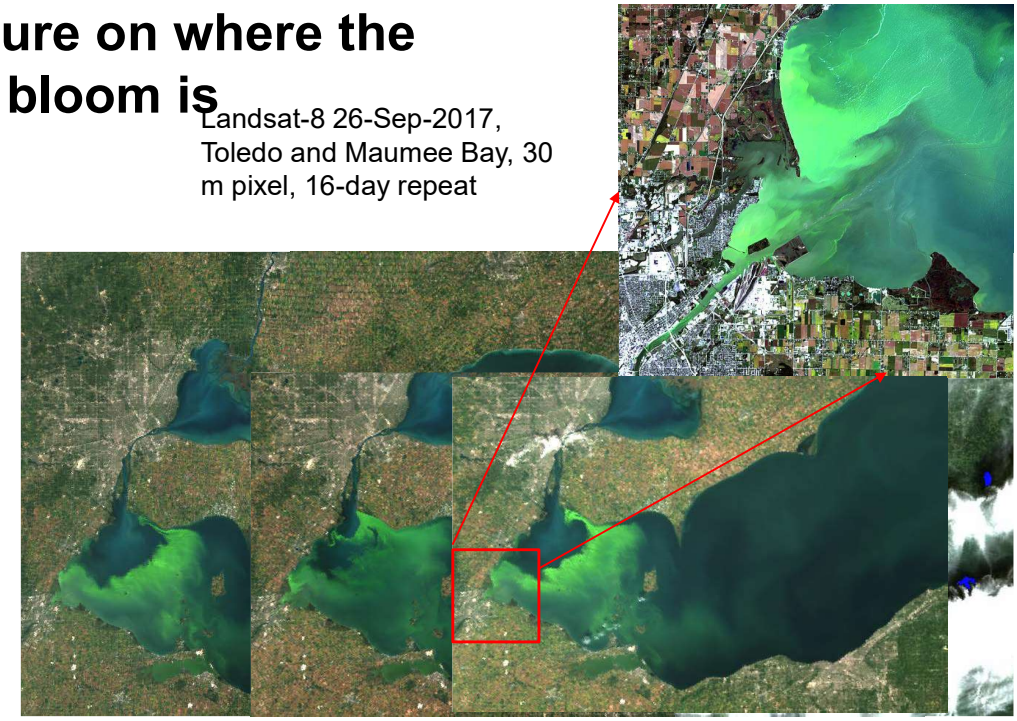


Big picture on where the bloom is

Sensor design:

Land vs water (frequency vs resolution)

Landsat-8 26-Sep-2017, Toledo and Maumee Bay, 30 m pixel, 16-day repeat



Copernicus Sentinel-3, 2017: 22,23,26 Sep, 01 Oct. 300 m pixel

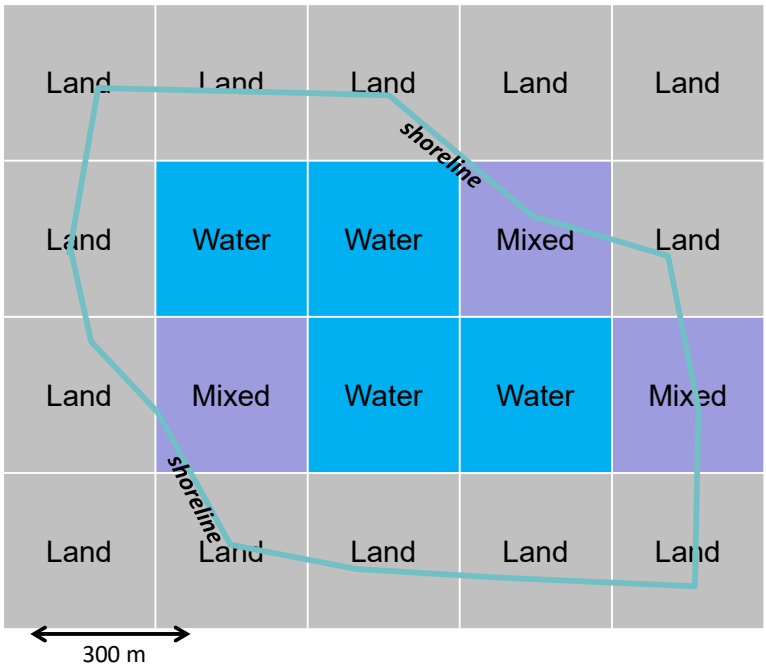
Satellite Comparison for lake/estuary applications

Satellite	Spatial	Temporal	Key Spectral
MERIS 2002-12 OLCI Sentinel-3a 2016-	300 m OK	1-2 day good	10 (5 on red edge) good
MODIS high res Terra 1999; Aqua 2002	250/500 m OK	1-2 day good	4 (1 red, 1 NIR) marginal
MODIS low res	1 km poor	1-2 day good	7-8 (2 in red edge) OK
VIIRS 2012-	750 m good	1 day good	6 (1 in red edge) marginal
Landsat-8	30 m good	16 day poor	4 (1 red, 1 NIR) marginal
Sentinel-2 (2015)	20 m good	5 day (starting 2018) Potential with 2	5 (1 red; 2 NIR, 1 in red edge) potential

Water Body, resolution and limits on detection

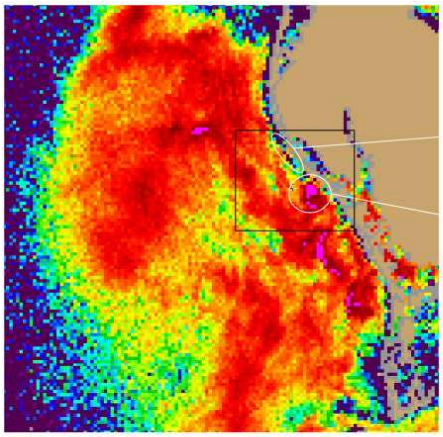
3 Pixels minimum width

Cannot detect algae if any land is in pixel

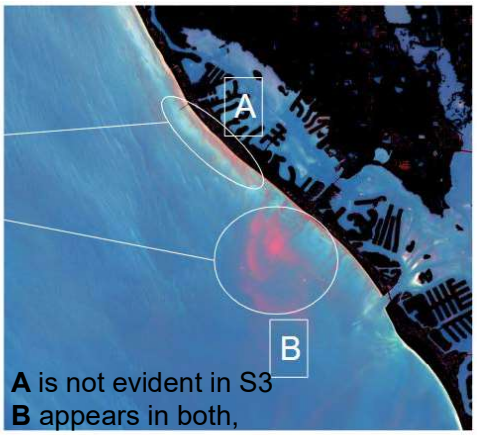


Merge resolutions to get to the shoreline

Sentinel-3 (300 m) 5 days/week, Sentinel-2 (20 m) 5-day repeat



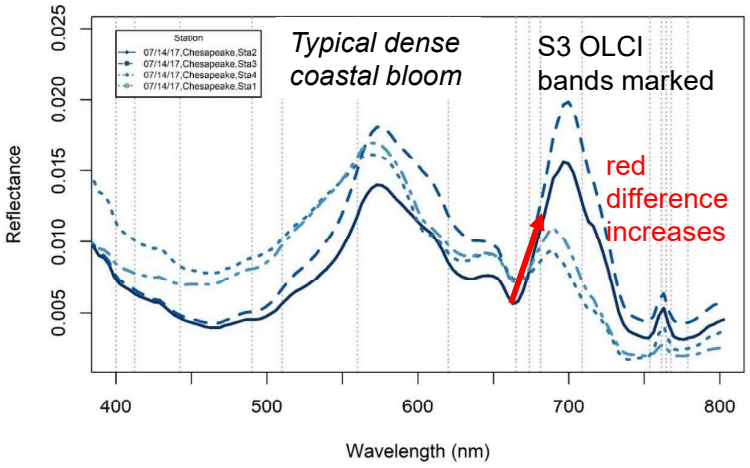
21 Oct 2018

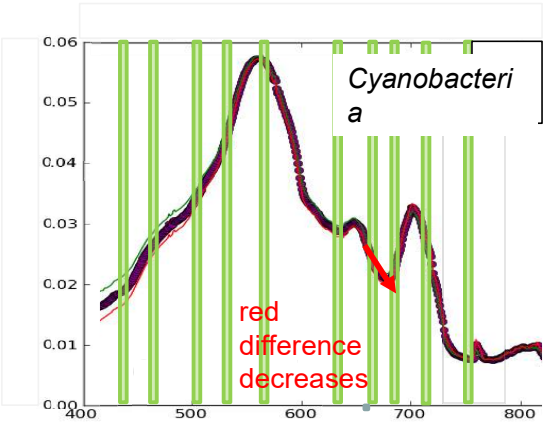


A is not evident in S3
B appears in both,
S2 is optically less sensitive, and less spectral resolution

Typical dense algal bloom spectra, with hyperspectral data (with OLCI/MERIS bands)

Similar for many phytoplankton, but some optical separation





Major Karenia brevis "red tide"
satellite bloom comparison July and Sep 2018

Image date: 2018-07-17

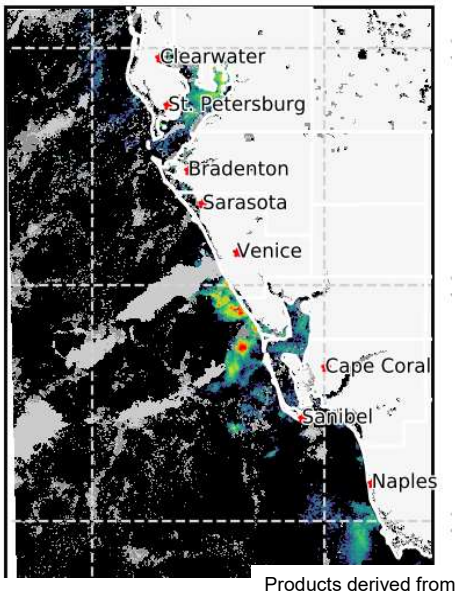
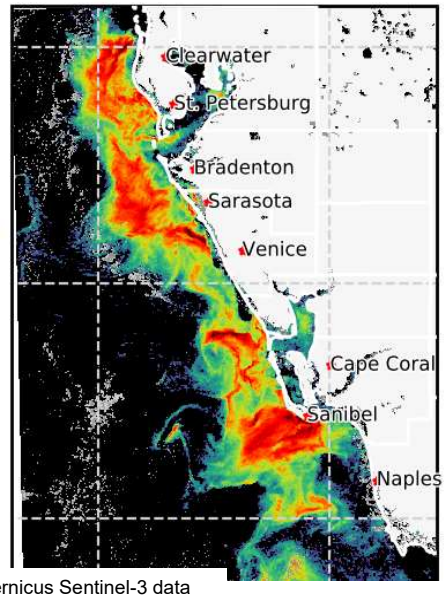


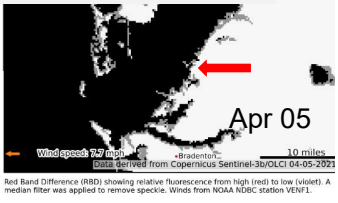
Image date: 2018-09-17



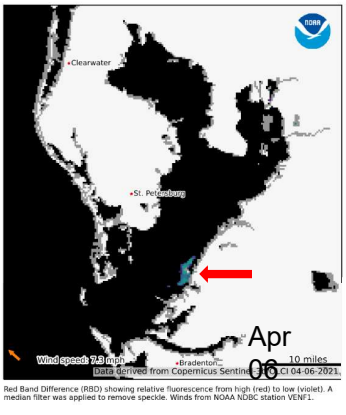
Products derived from Copernicus Sentinel-3 data

Other concerns: bloom during a water quality issue Piney Point, FL April 2021

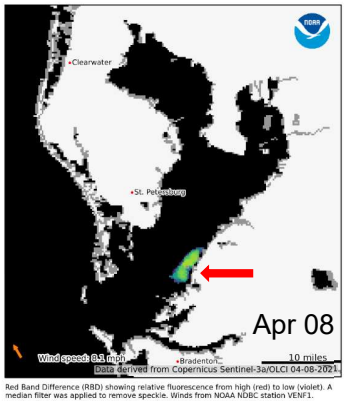
Wastewater discharged into Tampa Bay from old phosphate site (Mar 26 - Apr 09). Algal bloom developed. **Not harmful at this time.**



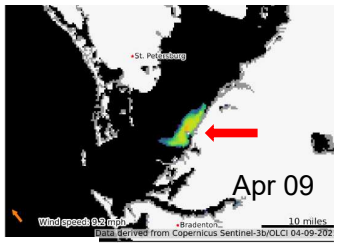
Red Band Difference (RBD) showing relative fluorescence from high (red) to low (violet). A median filter was applied to remove speckle. Winds from NOAA NDBC station VENF1.



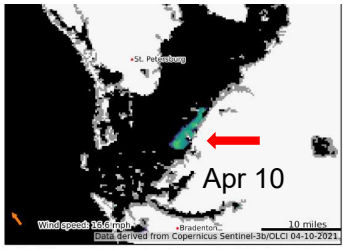
Red Band Difference (RBD) showing relative fluorescence from high (red) to low (violet). A median filter was applied to remove speckle. Winds from NOAA NDBC station VENF1.



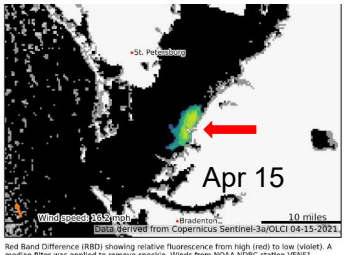
Red Band Difference (RBD) showing relative fluorescence from high (red) to low (violet). A median filter was applied to remove speckle. Winds from NOAA NDBC station VENF1.



i) showing relative fluorescence from high (red) to low (violet). A to remove speckle. Winds from NOAA NDBC station VENF1.



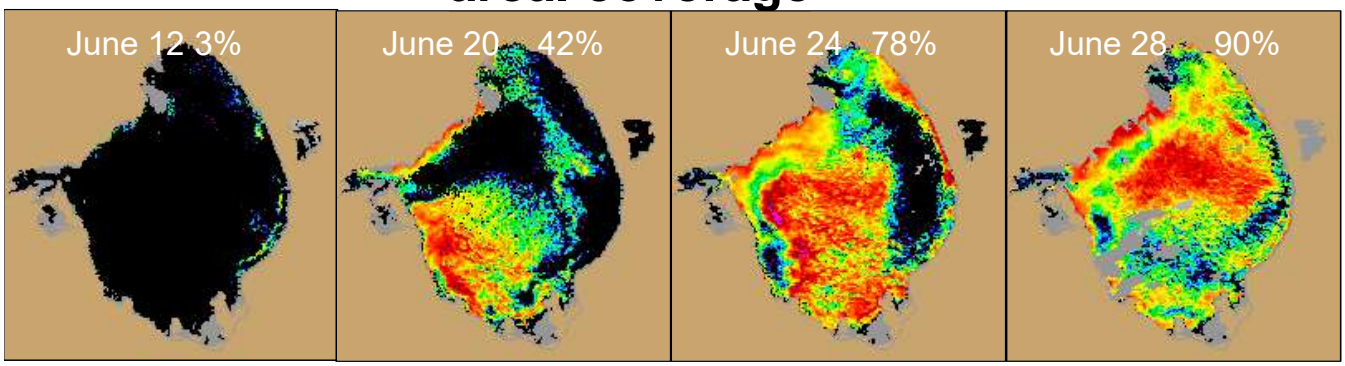
Red Band Difference (RBD) showing relative fluorescence from high (red) to low (violet). A median filter was applied to remove speckle. Winds from NOAA NDBC station VENF1.



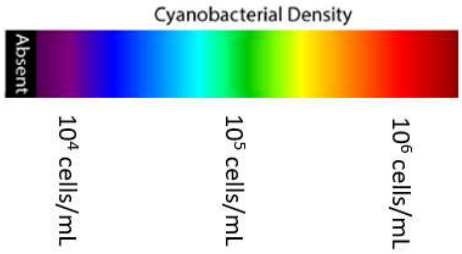
Red Band Difference (RBD) showing relative fluorescence from high (red) to low (violet). A median filter was applied to remove speckle. Winds from NOAA NDBC station VENF1.

https://go.usa.gov/xH4S7

Cyanobacteria, Lake Okeechobee, 2018, areal coverage



35 km



EPA CyAN APP 2000 lakes

https://go.usa.gov/xH8em

"Optics" from satellite pixels are insufficient to find blooms

Bio-optically-based is the "Holy Grail" (not achievable)

Good for cyano discrimination with enough bands

not specific to *toxic* dinoflagellates (diatoms look similar)

Need ecological conditions

blooms depend on temperature, salinity, geography….

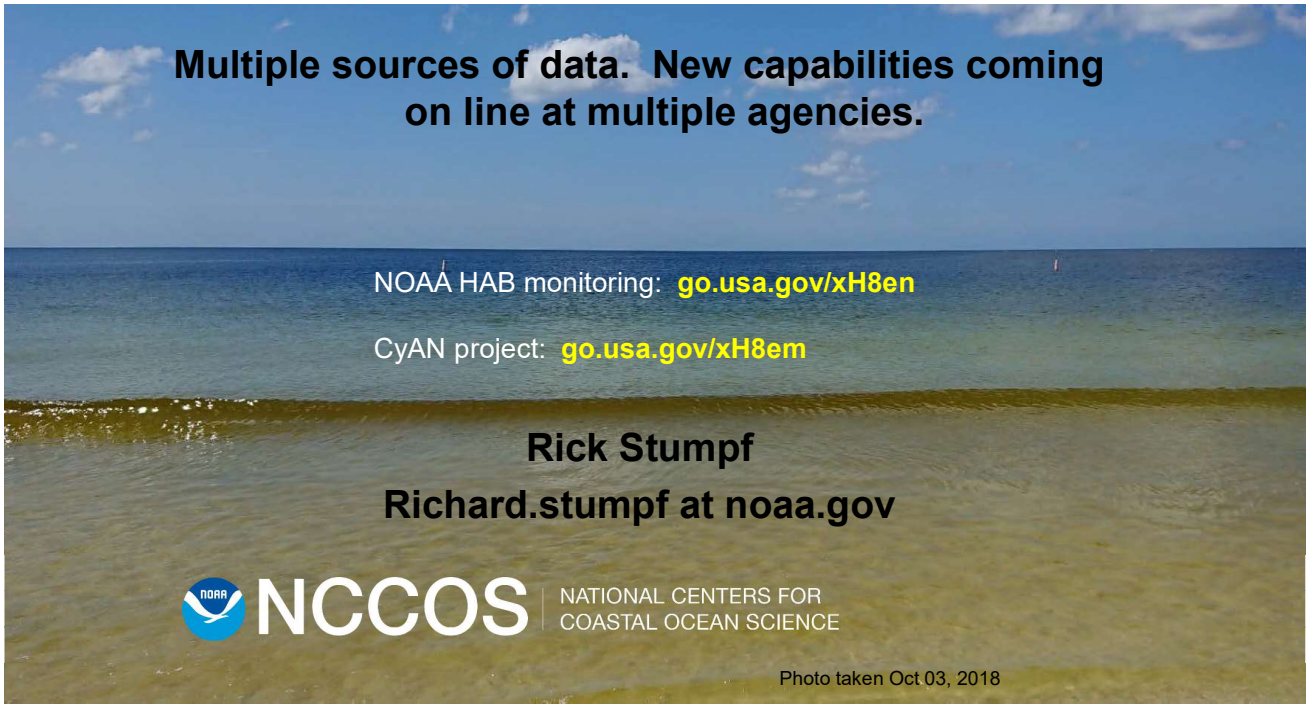
Need biology

dinoflagellates swim (diatoms don't), more variation

Need Spatial/temporal patterns

blooms are patches not pixels and last for weeks

each image is not a blank slate



Remote Sensing of Algal Blooms in Small Inland Waterbodies

Tyler King

USGS
Idaho Water Science Center

Apr 2021

Brownlee Reservoir, 2020-07-06
Photo Credit: Idaho Power Company

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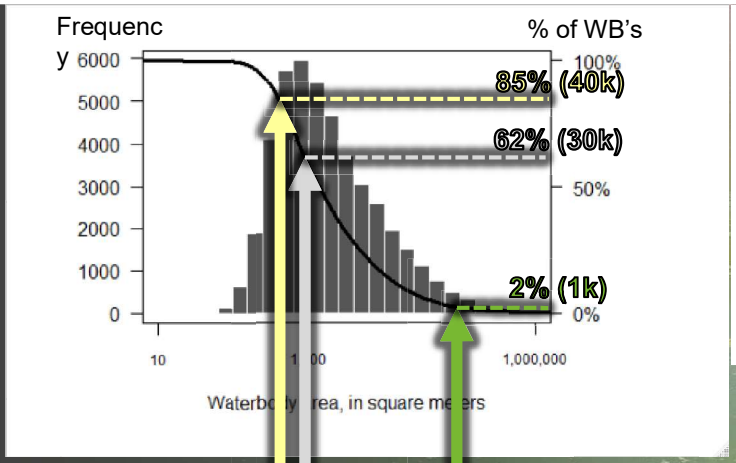
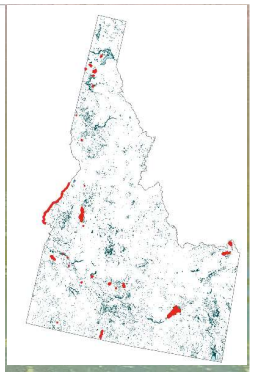
Smaller Waterbodies

- Common
- Experience blooms
- Require high spatial resolution imagery
- High spatial resolution comes at a cost





Satellite Comparison for lake/estuary applications

Satellite	Spatial	Temporal	Key Spectral
MERIS 2002-12 OLCI Sentinel-3a 2016-	300 m	1-2 day	10 (5 on red edge)
MODIS high res Terra 1999; Aqua 2002	250/500 m	1-2 day	4 (1 red, 1 NIR)
MODIS low res	1 km	1-2 day	7-8 (2 in red edge)
VIIRS 2012-	750 m	1 day	6 (1 in red edge)
Landsat-8	30 m	16 day	4 (1 red, 1 NIR)
Sentinel-2 (2015)	20 m	5 day (starting 2018)	5 (1 red; 2 NIR, 1 in red edge)

Company

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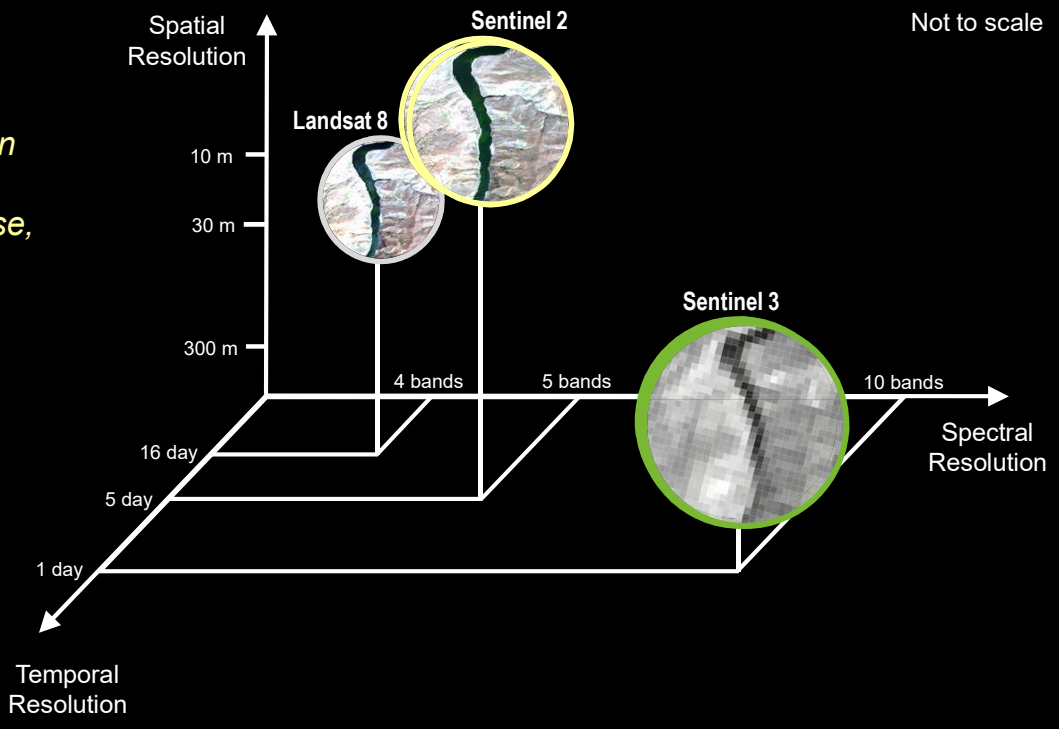
Trade-off space

What information can we extract from "data sparse, pixel rich" imagery?



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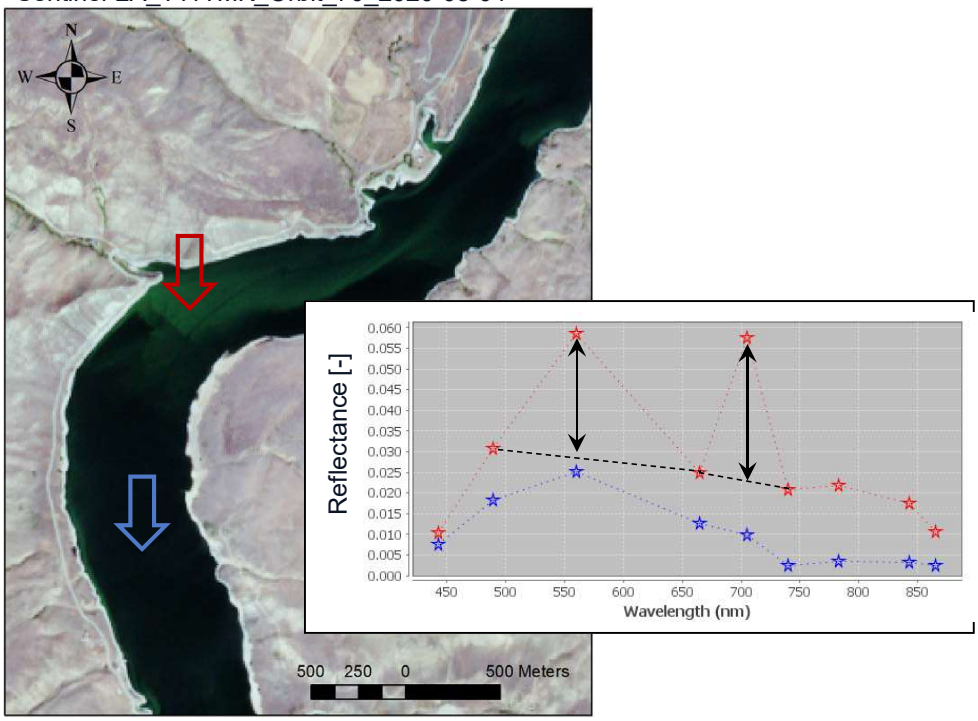
Extracting Information from "data sparse, pixel rich" imagery

- Quantify magnitude of spectral features associated with algal blooms
- Elevated green light (~550 nm)
- Elevated near-infrared (~700 nm)
- Consistent with Chlorophyll-a

Sentinel-2A_T11TMK_Orbit_70_2020-08-04



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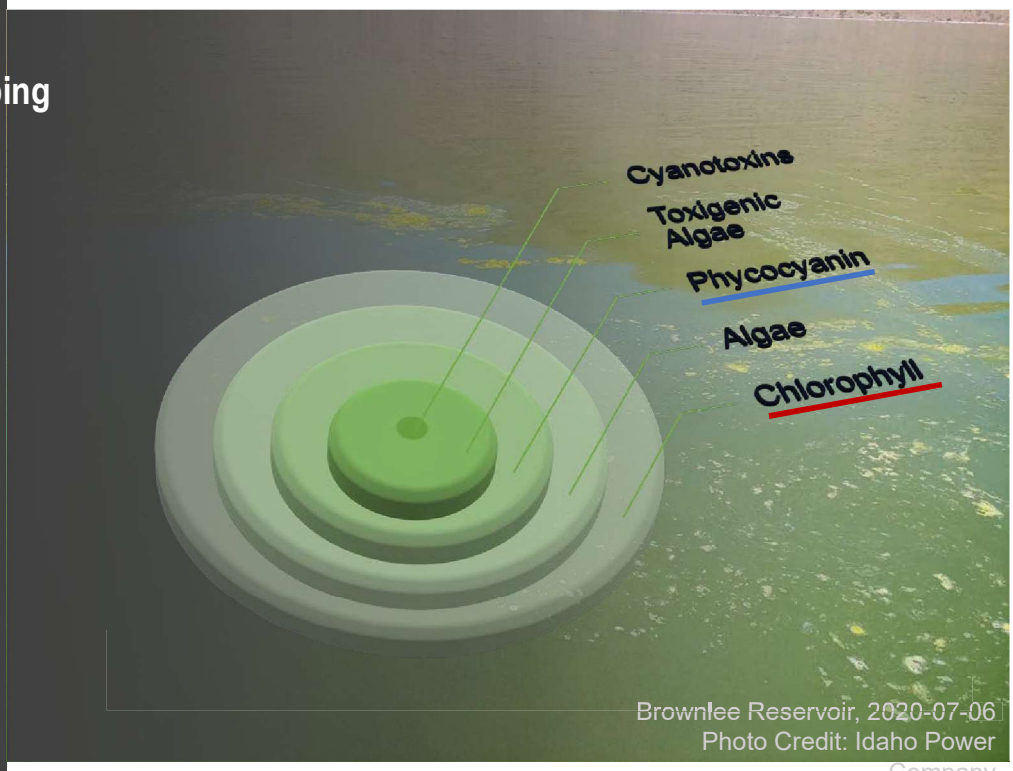
Benefits and Limitations of Mapping Chlorophyll-a

- High spatial resolution imagery currently gets us to mapping chlorophyll-a
- Chlorophyll-a can be a useful precursor to identifying algal blooms
- Other pigments closer to the "bullseye" are detectable with OLCI and other sensors
- No ability to remotely sense toxins directly



Brownlee Reservoir, 2020-07-06
Photo Credit: Idaho Power Company

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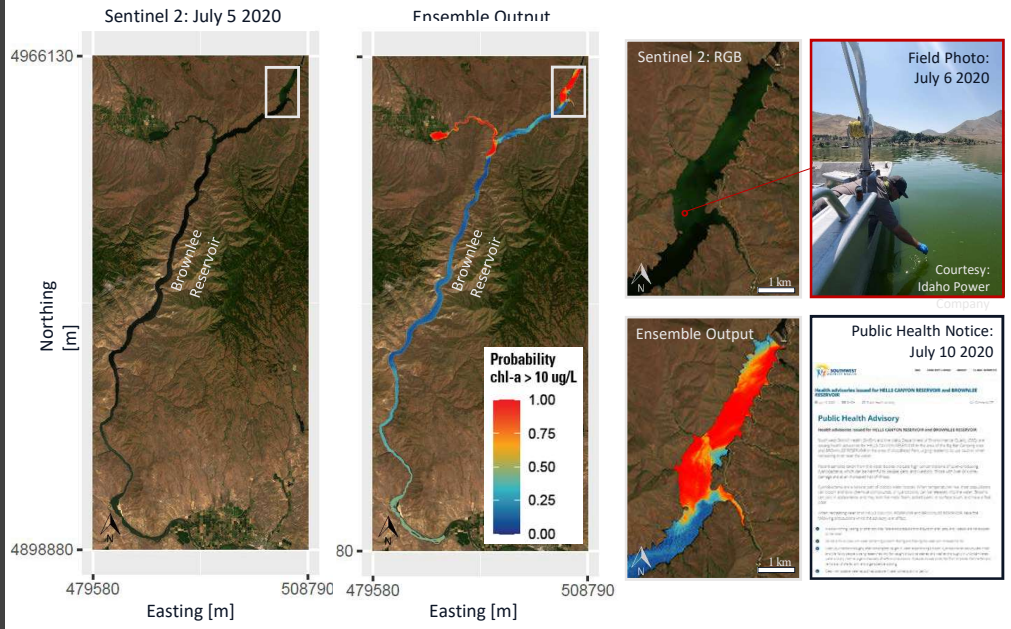
Example Application

- Imagery collected: 11 am July 5th
- Imagery processed: 6pm July 5th
- Cooperator Sampling: July 6th
- Laboratory Testing: July 7 – 10th
- Public Health Notice: July 10th
  - Anatoxin-a & Microcystin



Brownlee Reservoir, 2020-07-06
Photo Credit: Idaho Power Company

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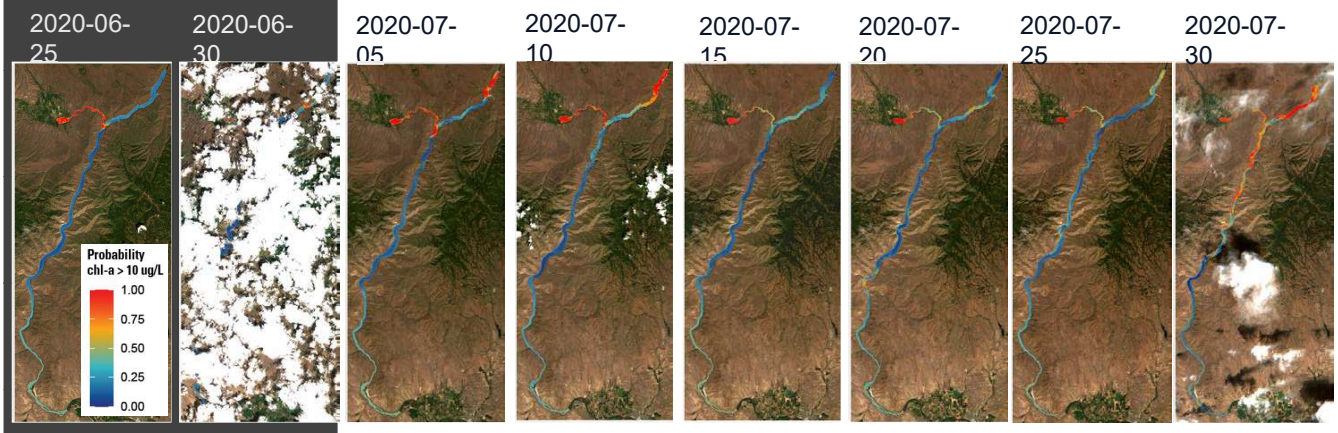

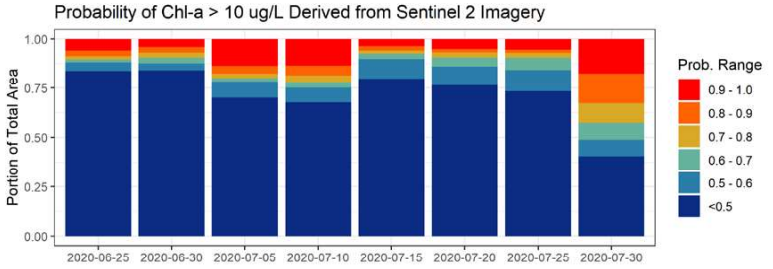

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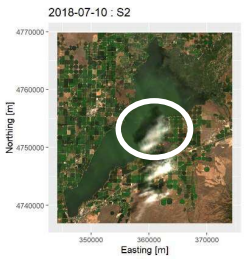
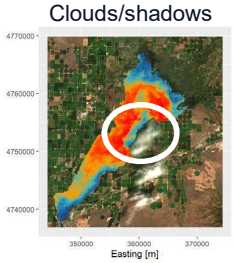
Limitations

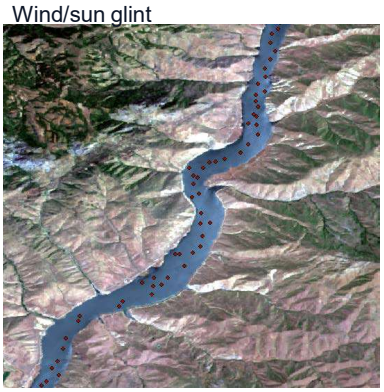
Does not differentiate between cyanobacteria and other algae

Transferability

Interference
- Clouds/Shadows
- Smoke
- Sediment
- Wind/sun glint
- Bottom reflection
- Aquatic vegetation
- Ice
- Boats/docks







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Resources and thank you:

	Full Resolution Online	Interactive Image Processing	Display Derived Products	Download Raw Imagery	Mobile Friendly	High Spatial Resolution	Links
EarthExplorer				✓+		✓	EarthExplorer.usgs.gov
EO Browser	✓	✓+	✓			✓	apps.sentinel-hub.com/eo-browser/
Sentinel Hub Playground	✓	✓	✓		✓	✓	apps.sentinel-hub.com/sentinel-playground/
Copernicus DHuS				✓+		✓	scihub.copernicus.eu/dhus/
CyAN App	✓		✓+		✓+		https://go.usa.gov/xH8em
NCCOS HABs Monitoring System	✓		✓+	✓			https://go.usa.gov/xH8en

Tyler King
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Harmful Algal Bloom Preparedness and Response Workshop

4/28/2021

Cyanotoxin Measurement for Event-Response

Keith Loftin

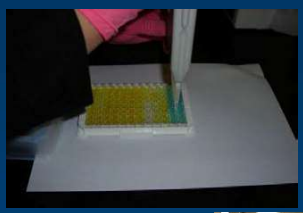
Science Lead, USGS Environmental Health Toxins and HABs Integrated Science Team

Supervisor, Algal and Other Environmental Toxins Laboratory,

U.S. Geological Survey Kansas Water Science Center

U.S. Department of the Interior
U.S. Geological Survey

Non-Target and Target Analytical Methods for Cyanotoxin Measurement



- Assays
  - Mode of Action Assays (e.g. enzyme inhibition, receptor binding)
  - Enzyme-linked Immunosorbent Assays (ELISAs)
- Liquid Chromatography/Detectors
  - Ultraviolet-visible
  - Fluorescence
  - Mass Spectrometry (different types)

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Cyanotoxin Method Selection

Analysis Time

Method Type	Best Suited Use	Instrumentation Cost	Field or Lab Useable	Laboratory Infrastructure	Analyst Expertise	Analysis Cost/Sample	Cyanotoxin Specificity
ELISA (Field use)	Qual	~$2K - $5K	Both	-	+	++	++
ELISA (96 Well Plates)	Qual / Semiquant	$3K - $150K	Lab	+	+ / ++	+	++
Mode of Action Assays:							
Acetylcholinesterase Inhibition	Semiquant / Quant	$3K - $150K	Lab	+	+ / ++	+	+
Nicotinic Acetylcholine Receptor Binding Assay	Semiquant / Quant	$3K - $150K	Lab	+	+ / ++	+	+
Protein Phosphatase Inhibition	Semiquant / Quant	$3K - $150K	Lab	+	+ / ++	+	+
Liquid Chromatography (LC)/							
Diode Array Detection (UV/Vis)	Quant	$100K - $150K	Lab	++	++	+++	+++
Fluorescence Detection	Quant	$100K - $150K	Lab	+++	+++	+++	+++
Single Quadrupole (MS)	Quant	$150-$250K	Lab	++++	++++	+++	++++
Triple Quadrupole (MS/MS)	Quant	$250K - $400K	Lab	++++	++++	++++	++++
High Resolution Mass Spectrometry	Qual / Quant	> $500K	Lab	+++++	+++++	+++++	+++++

The number of "+" indicate an increase in the order of magnitude for a particular category of the method relative to all other methods on the slide.

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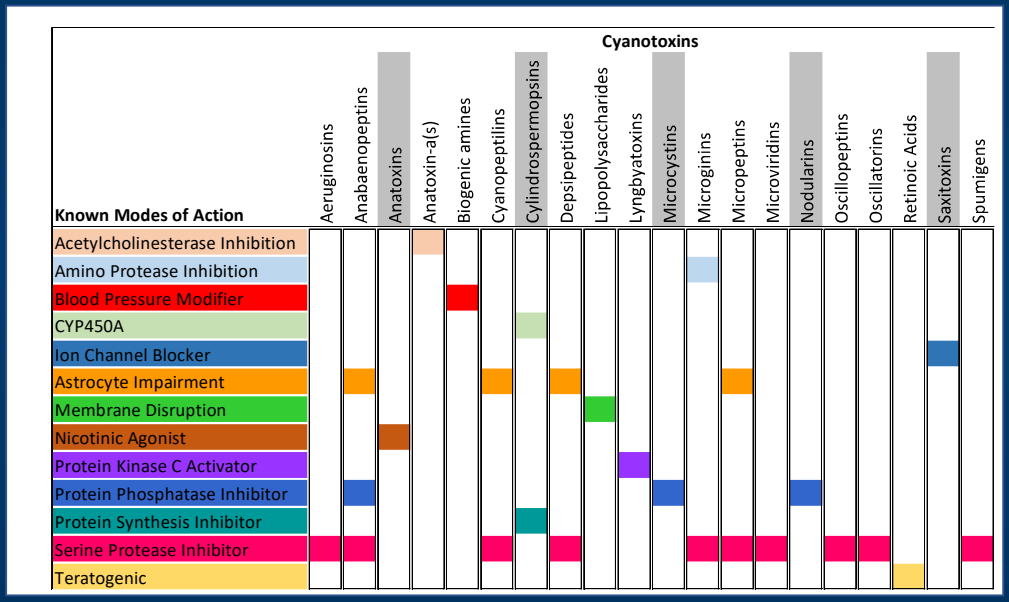
Many Classes of Cyanotoxins and Their Modes of Action

- Commercially available kits:
  - ACHEI
  - Nicotinic Agonist
  - PP2A



Summarized from Handbook of Cyanobacterial Monitoring and Cyanotoxin Analysis, 2017

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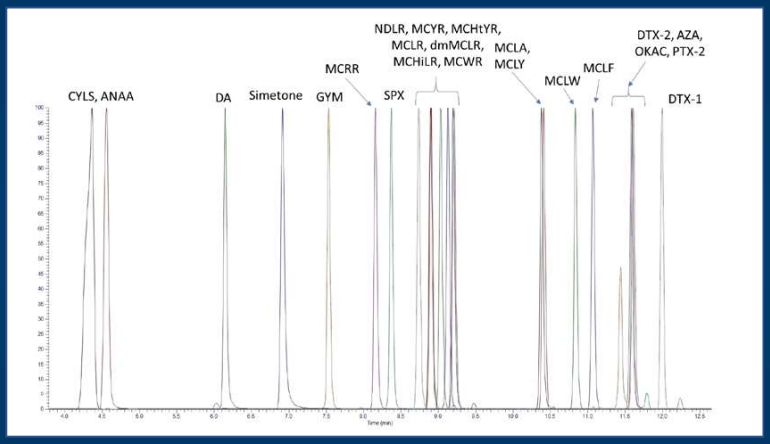
High Resolution Mass Spectrometry Can Fulfill Quantitative Analysis Needs.



Bioinert Thermo Vanquish LC/ Thermo Orbitrap QE+ HRMS Chromatogram

Sample	ANAA			MCLA			MCLR			MCRR			MCYR		
	QQQ (µg/L)	Orbitrap (µg/L)	%RSD	QQQ (µg/L)	Orbitrap (µg/L)	%RSD	QQQ (µg/L)	Orbitrap (µg/L)	%RSD	QQQ (µg/L)	Orbitrap (µg/L)	%RSD	QQQ (µg/L)	Orbitrap (µg/L)	%RSD
JLA 56384A	<0.08	<0.08	--	0.3	0.14	51.4	1.15	1.3	8.7	0.65	0.61	4.5	0.26	0.1	62.9
JLA 56423A	0.62	0.79	17.1	<0.10	<0.10	--	0.96	1.12	10.9	0.56	0.56	0.0	<0.10	<0.10	--
JLA 56457A	<0.08	<0.08	--	<0.10	<0.10	--	0.15	0.21	23.6	0.12	0.12	0.0	0.14	<0.10	--

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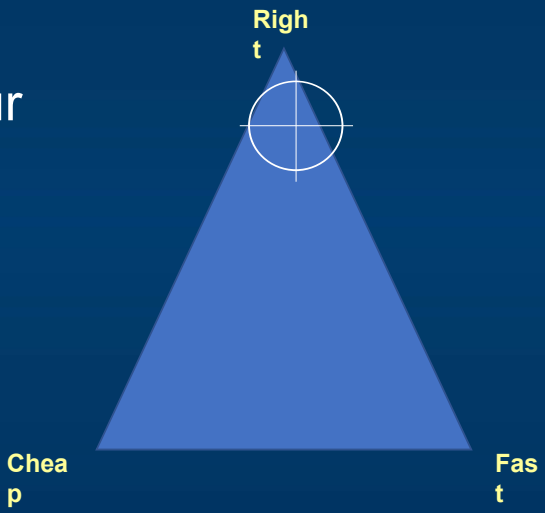
Cyanotoxin Measurement is Always About the Details and Tradeoffs…

- What is most important to your event-response scenario?
  - Cheap
  - Fast
  - Right

Little Haynes Creek, GA
Courtesy: Alan Cressler



What are you aiming for?

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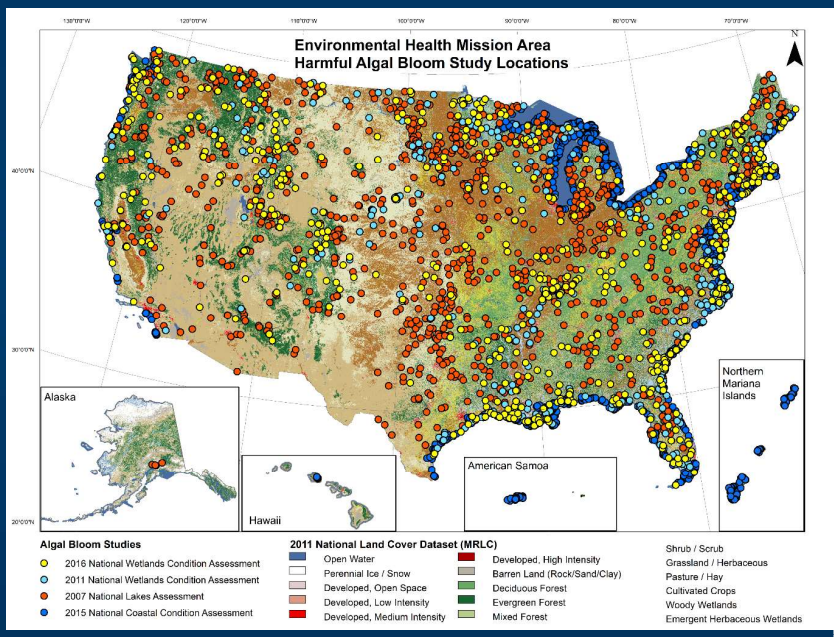
Cyanotoxins are in all U.S. Surface Water Types

Partner Agencies:



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Contact Information

Keith Loftin
US Geological Survey
785-764-1408
kloftin@usgs.gov

- USGS Environmental Health Toxins and HABs IST
- USGS Algal and Other Environmental Toxins Laboratory
- USGS GeoHealth Newsletter - Algal Toxins
- USGS KS WSC OGRL Algal Toxins

Trade names are for descriptive purposes only and does not imply endorsement by the U.S. Government.

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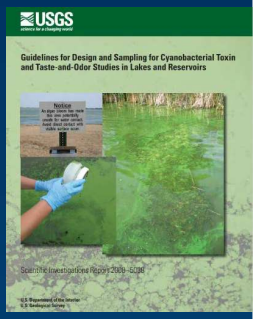
Additional Resources

- Toxic cyanobacteria in water - Second edition (who.int)
- Guidelines for Design and Sampling for Cyanobacteria Toxin and Taste-and-Odor Studies in Lakes and Reservoirs SIR2008-5038.pdf (usgs.gov)
- Chapter A7. Section 7.5. Cyanobacteria in lakes and reservoirs: Toxin And taste-and-odor sampling guidelines (usgs.gov)
- Selected Analytical Methods for Environmental Remediation and Recovery (SAM) 2017 | Science Inventory | US EPA - Biotoxins



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Harmful Algal Bloom Preparedness and Response Workshop

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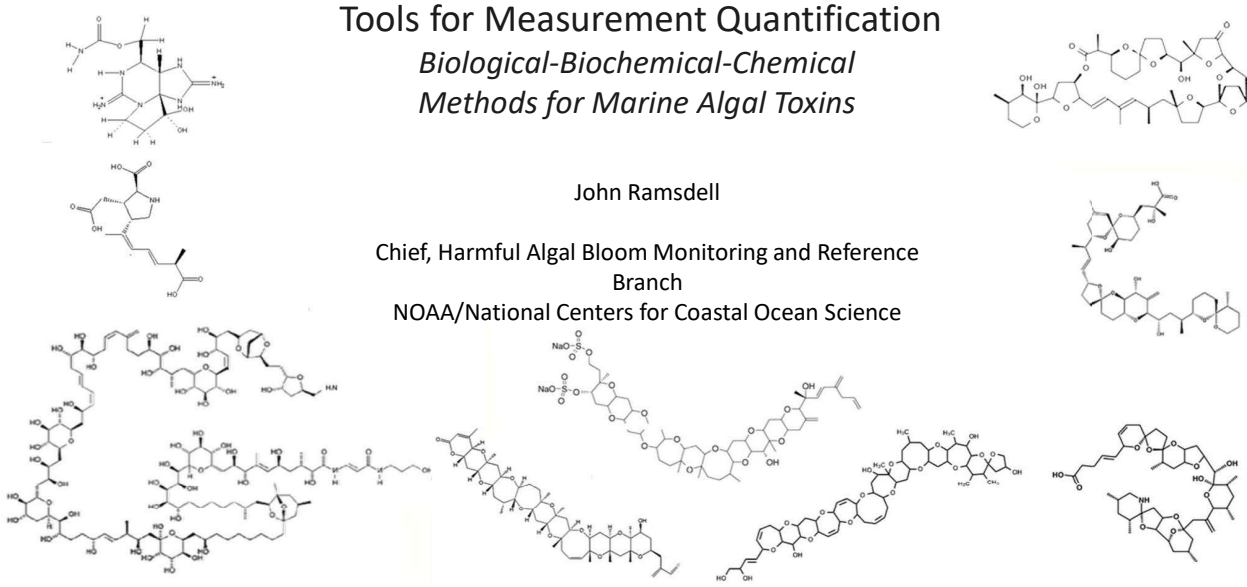
Tools for Measurement Quantification

Biological-Biochemical-Chemical Methods for Marine Algal Toxins

John Ramsdell

Chief, Harmful Algal Bloom Monitoring and Reference Branch
NOAA/National Centers for Coastal Ocean Science



Detection Methodologies

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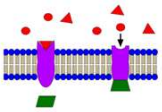
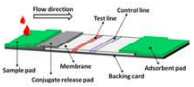
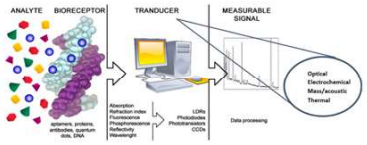
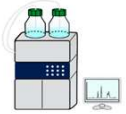
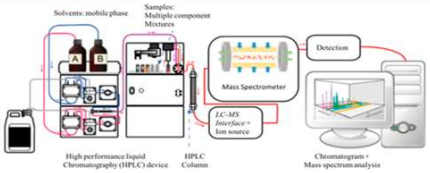
BIOLOGICAL METHODS	 Mouse bioassay	 Cell based Assays	 Receptor based Assays
BIOCHEMICAL METHODS	 ELISA	 Lateral flow devices	 Biosensor Methods
CHEMICAL METHODS	 HPLC-UV HPLC-FLD	 LC-MS/MS	

from Dillon et al. Sensors 2021, 21(7), 2499

Biological-Concept

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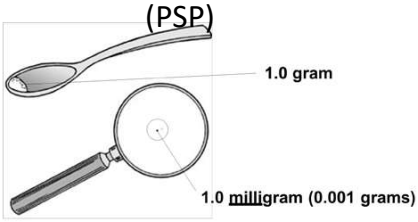
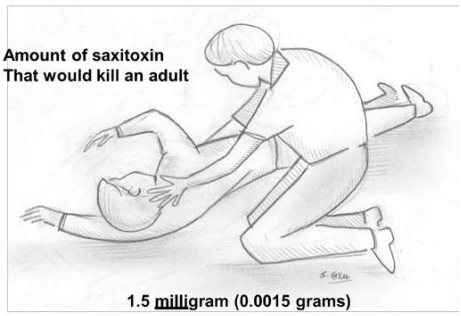
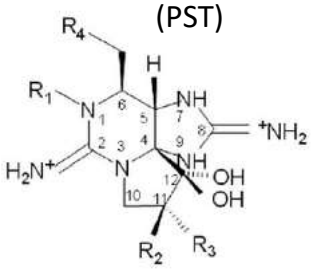
Paralytic Shellfish Poisoning (PSP)



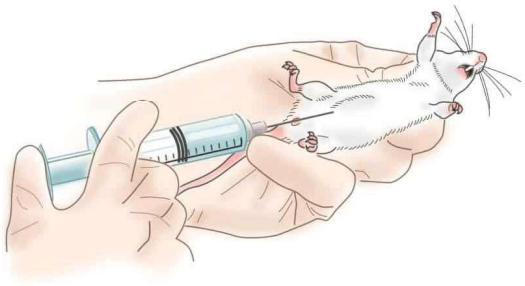


Paralytic Shellfish Toxins (PST)



			R4 Carbamoyl	Sulfocarbamoyl	Decarbamoyl	Benzoate
R1	R2	R3				
H	H	H	STX	GTX5	dcSTX	GC3
H	H	OSO_3^-	GTX2	C1	dcGTX2	GC1
H	OSO_3^-	H	GTX3	C2	dcGTX3	GC2
OH	H	H	Neo	GTX6	dcNeo	GC6*
OH	H	OSO_3^-	GTX1	C3	dcGTX1	GC4*
OH	OSO_3^-	H	GTX4	C4	dcGTX4	GC5*

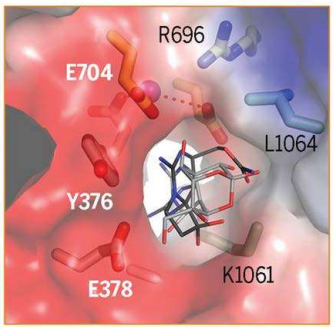
Biological-Animal Bioassay

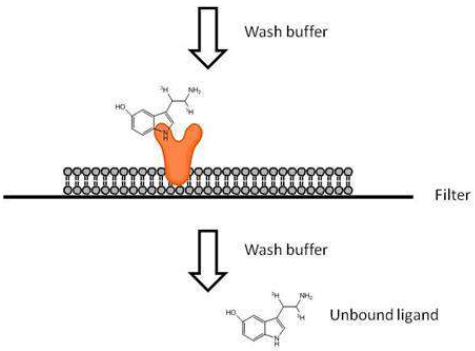


Five or more male mice, weighing 19–21 are intraperitoneally (i.p.) injected with 1 m*l* of acid extract of a shellfish sample, and the time of death (the time from the end of the injection to the last gasp of breath) is observed.

Mouse no.	BW (g)	BWCF	Lethal time (s)	MU	Corrected MU	Median MU	Average±SD of MU
Experiment 1							
Operator 1							
1	19.61	0.988	314	1.836	1.815	1.611	1.581±0.168
2	19.83	0.995	353	1.628	1.620		
3	19.19	0.976	419	1.393	1.359		
4	20.34	1.010	389	1.484	1.499		
5	20.23	1.007	360	1.600	1.611		

Biological-Receptor Assay



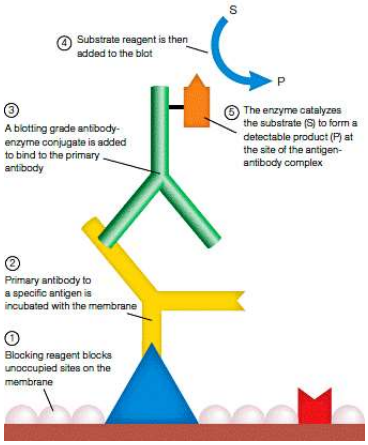


STEP 1: SAMPLE PREPARATION:
Acid extraction

STEP 2: ASSAY:
Plating of reagents

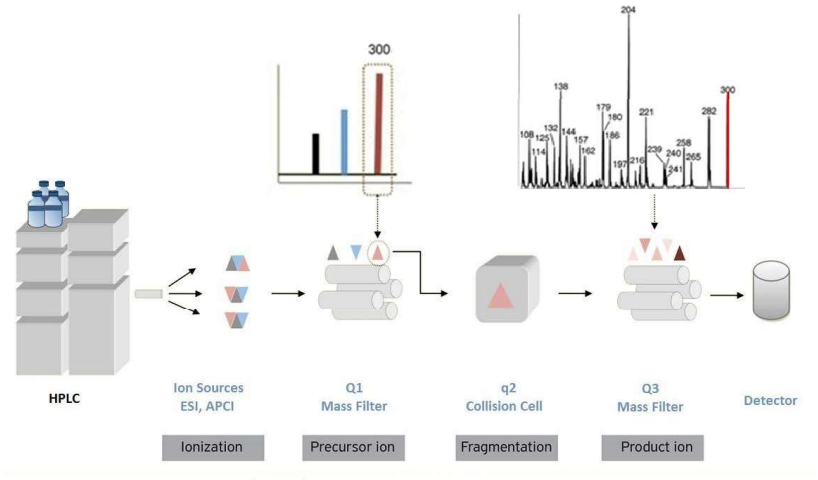
STEP 3: RESULTS:
Liquid Scintillation Counting

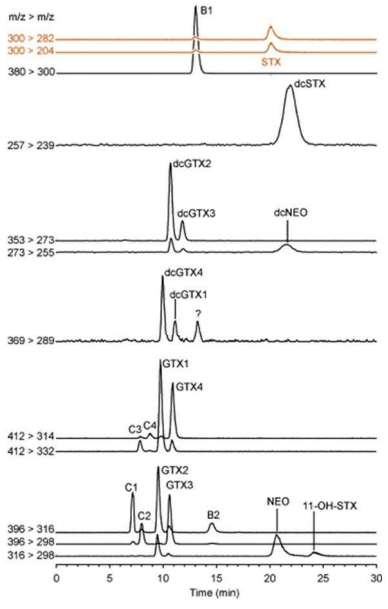
Biochemical-Test Strip, ELISA, Sensor



Some products and manufacturers are mentioned in descriptive information. Mention of these products or manufacturers does not constitute an endorsement by NOAA or the Department of Commerce.

Chemical-LC-MS/MS Analysis

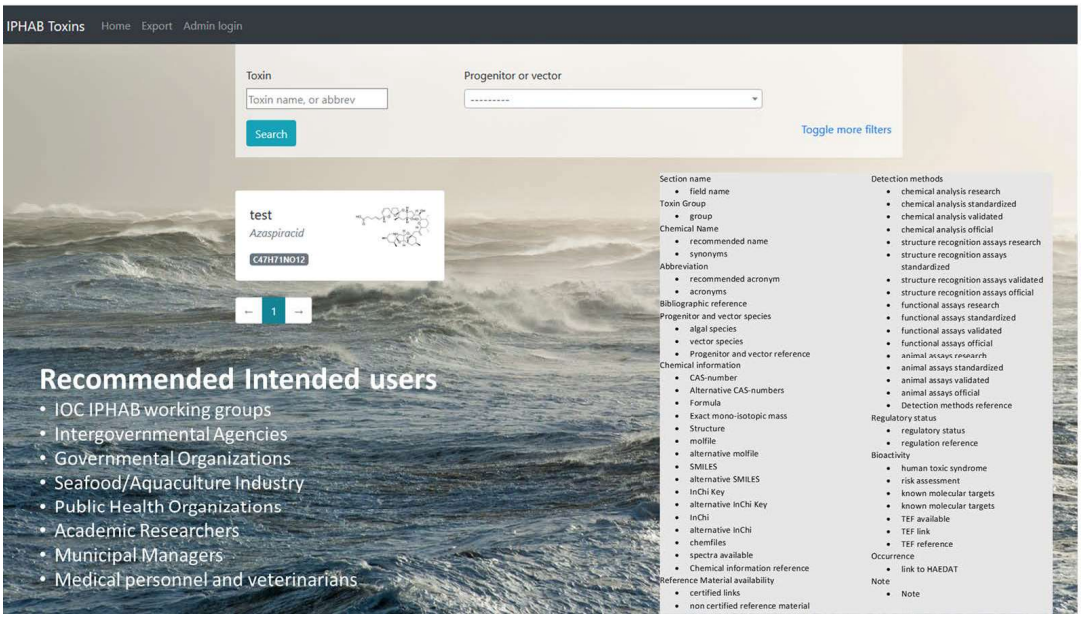




Modified from: Lazaro et al., Arquivos do Instituto Biológico 82:1, Sleno et al., J Am Soc Mass Spectrometry **15**: 462 and Dell'Aversano et al., J Chromatogr A. 1081:190

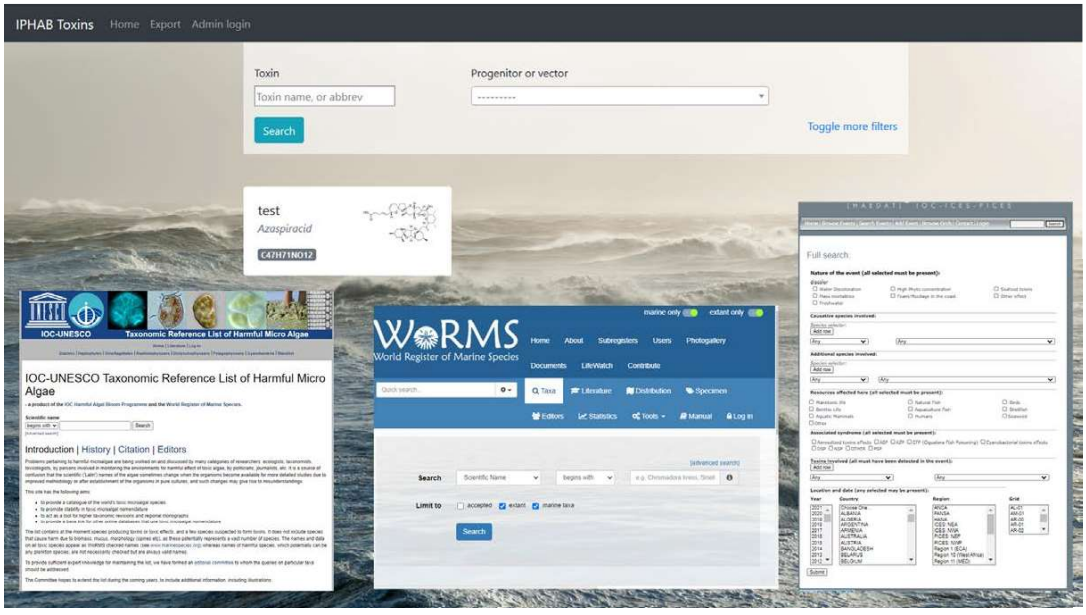
Access to Information

NCCOS | NATIONAL CENTERS FOR COASTAL OCEAN SCIENCE



Integration of Information

NCCOS | NATIONAL CENTERS FOR COASTAL OCEAN SCIENCE



National Center for Emerging and Zoonotic Infectious Diseases

Public Health Surveillance for Harmful Algal Blooms and Associated Illnesses

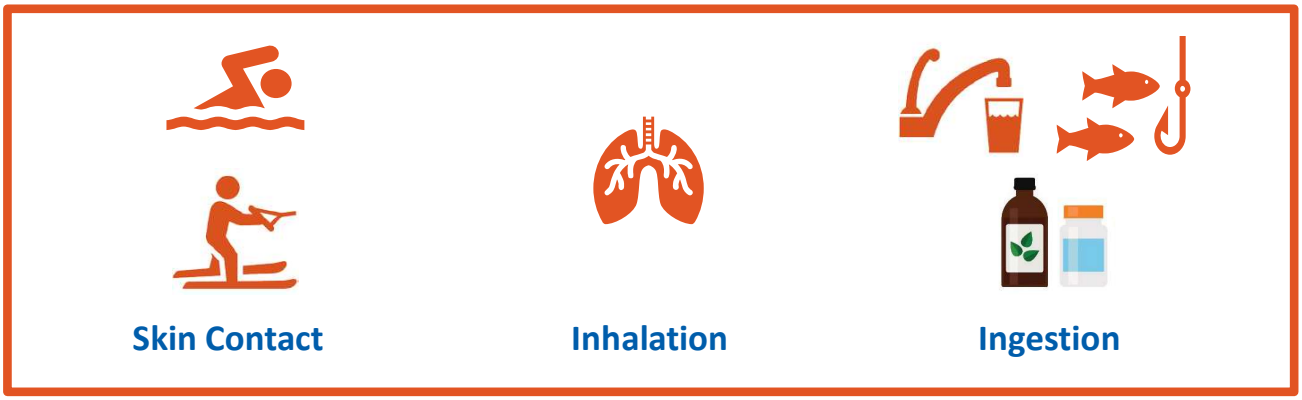
Virginia A. Roberts, MSPH

Epidemiologist

Harmful Algal Bloom (HAB) Preparedness & Response Workshop
April 28, 2021

Hosted by NOAA's Disaster Preparedness Program and the University of New Hampshire's Coastal Response Research Center

People and animals can be exposed to harmful algae, cyanobacteria, and their toxins via multiple exposure pathways

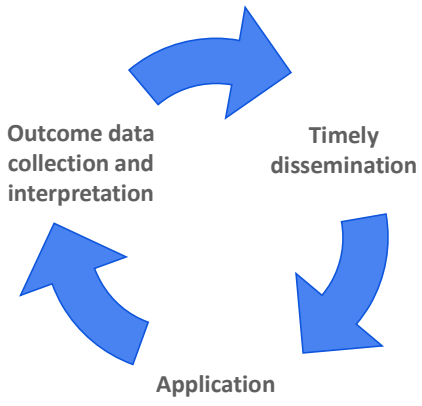


What types of public health questions still need answering?

- Frequency and geographic distribution
- Illness characterization
- Risk factors
- Prevention efforts

Public health surveillance refers to the collection, analysis, and use of data to target public health prevention.

- **Foundational to public health practice**
  - ***Ongoing, systematic collection, analysis, and interpretation of outcome-specific data***
  - ***Data are used in the planning, implementation, and evaluation of public health practice.***

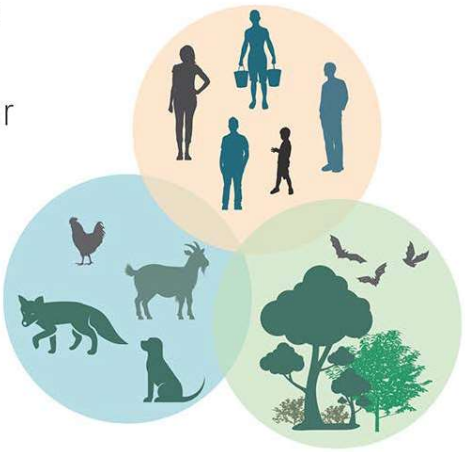


CDC Surveillance Resource Center | CDC

Teutsch and Churchill , Principles and Practice of Public Health Surveillance. 2000. Oxford University Press

CDC utilizes a One Health approach…

One Health is the idea that the health of people is connected to the health of animals and our shared environment.



When we protect **one**, we help protect **all**.

www.cdc.gov/onehealth

CDC systems that collect surveillance data about HABs and associated illnesses

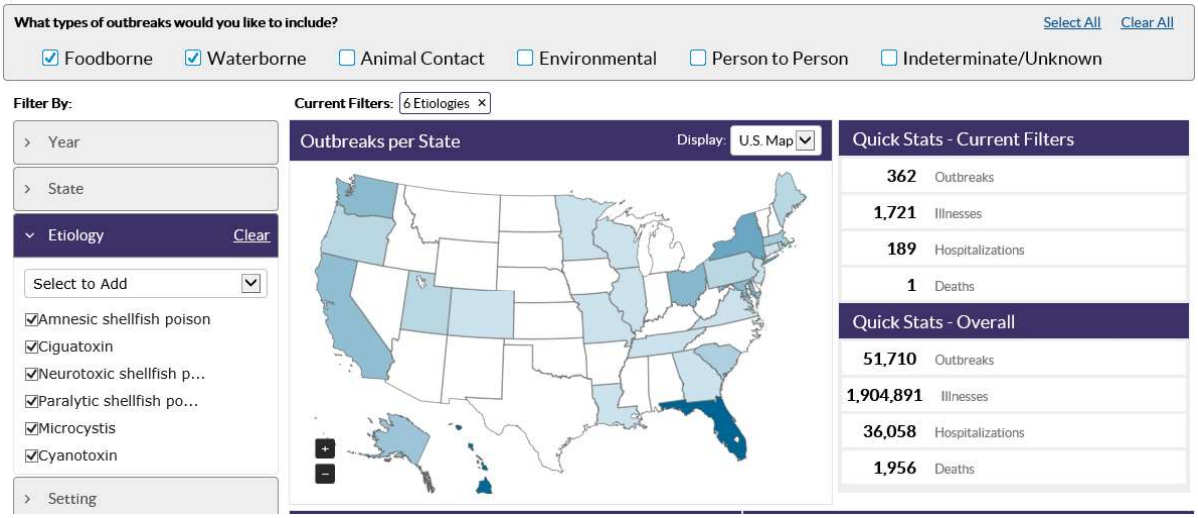
NORS
National Outbreak Reporting System

OHHABS
ONE HEALTH Harmful Algal Bloom System

National Outbreak Reporting System (NORS) | CDC

- Web-based, national
- Outbreaks
  - ≥ 2 human illnesses reported in aggregate (e.g., 2/7 people reported a skin rash, 1/7 reported coughing)

National Outbreak Reporting System (NORS) Dashboard | CDC



02/2021

One Health Harmful Algal Bloom System (OHHABS) | Harmful Algal Blooms | CDC

- Web-based, national
- Launched in 2016
- HAB events, human cases, animal cases
  - Case-level data
    - e.g., case #1 reported gastrointestinal illness, case #2 reported a headache and coughing, etc.)

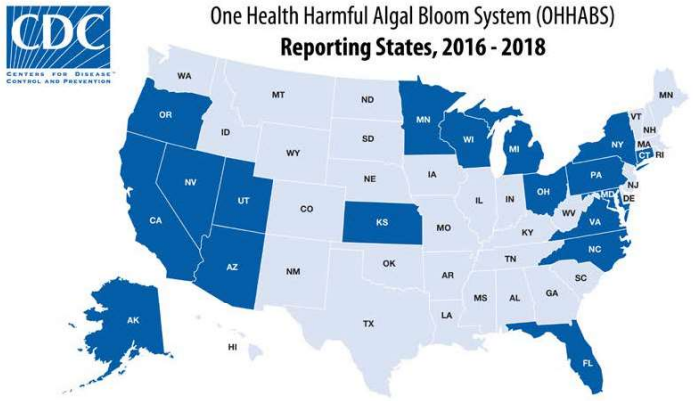
All OHHABS reports are classified using HAB event and case definitions

- Standardized classifications for HAB events, human cases, animal cases
- Supporting evidence: environmental, epidemiologic, and clinical data
- Current challenges include:
  - Access to diagnostic and environmental testing
  - Interpretation of testing results and other supporting evidence

For 2016—2018, 18 states were early adopters of OHHABS and reported 421 HAB events

389 human illnesses
- No deaths

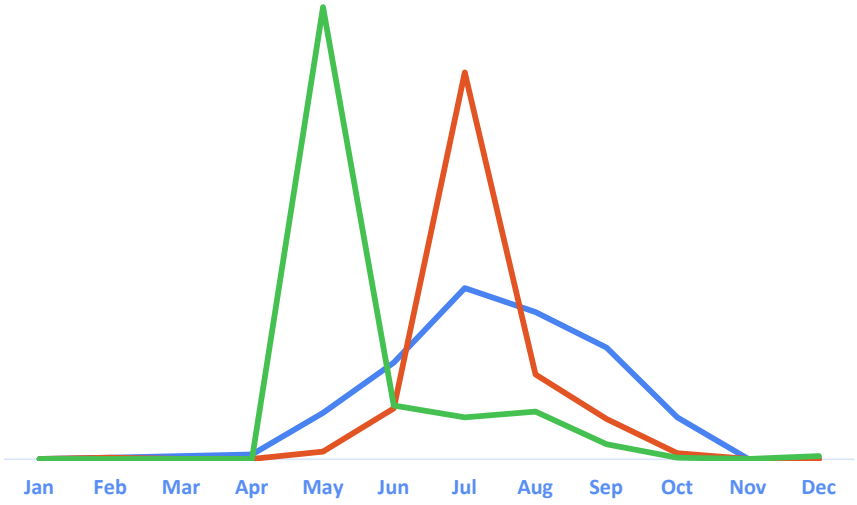
413 animal illnesses
- 369 deaths



https://www.cdc.gov/mmwr/volumes/69/wr/mm6950a2.htm?s_cid=mm6950a2_w

Almost all reported HAB events (90%) were freshwater cyanobacterial blooms

2 HAB events resulted in
- 51% of human cases
- 73% of animal cases



https://www.cdc.gov/habs/ohhabs_tables_and_figures.html

Both children and adults became ill and sought care primarily from poison control centers

At least 153 (39%) were <18 years old.

Time to illness onset (124 cases, one-time exposure): 1 minute to 8 days

Healthcare-seeking behavior: poison control centers (76%), health care providers (17%), emergency departments (9%), first aid care (1%)

Clinical specimen testing (8%)

- 4/5 tested by CDC confirmed to have exposures to saxitoxin or multiple toxins.

While a wide variety of animals became ill, most did not receive veterinary medical care

Domestic pets	Livestock	Wildlife
96%	86%	97%

Time to illness onset (21 cases, one-time exposure): 15 minutes to 4 days

Veterinary medical care or treatment was provided to 6% of all animals.

OHHABS data summary represents the launch of national public health surveillance for HAB events and illnesses in the United States

- A continued One Health approach to surveillance, paired with scientific research findings and increased access to specimen testing, will improve the system

Acknowledgements

Marissa Vigar
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Gabriella Veytsel
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Jonathan Yoder

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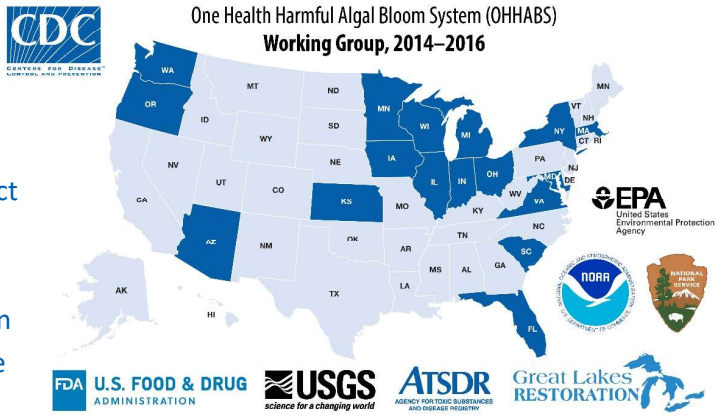
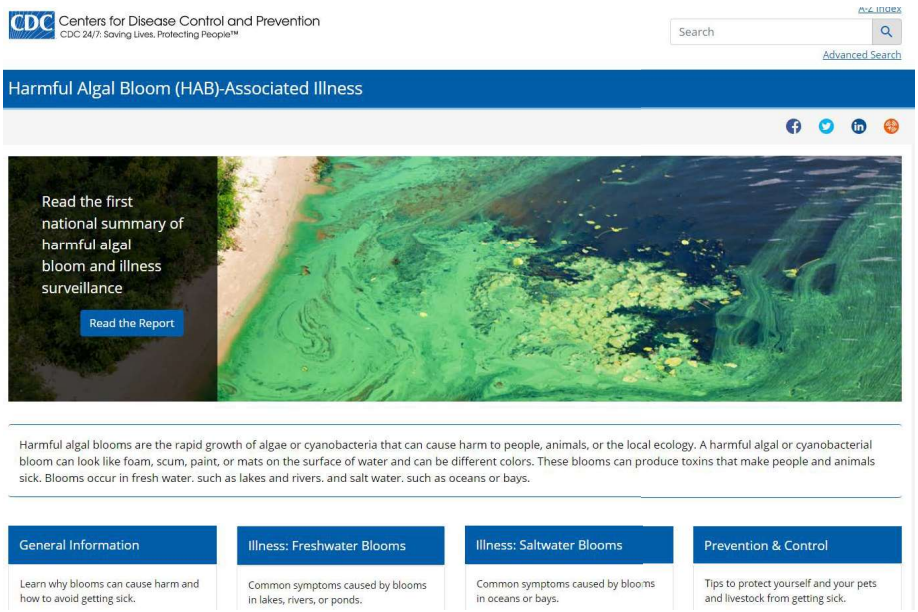
Michael Beach
Katharine Benedict
Sarah Collier
Victoria Cuéllar
Kathleen Fullerton
Radhika Gharpure
Amy Jacobi
Kevin O'Laughlin
Kayoko Shioda
Sathya Chakravarthy
Irina Pyrkh
Brian Rachel
Ashley Andujar
Sarah Segerlind



- State and local waterborne disease coordinators, epidemiologists, environmental health practitioners, laboratorians, toxicologists, and animal health practitioners
- Delaney Moore, BreAnne Osborn, (Utah Department of Health).

Learn more about HAB-associated illnesses and OHHABS



https://www.cdc.gov/habs/index.html

Thank you!

For more information, contact CDC
1-800-CDC-INFO (232-4636)
TTY: 1-888-232-6348 www.cdc.gov

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

Public Health Response: Exposures to Harmful Algal Bloom Toxins

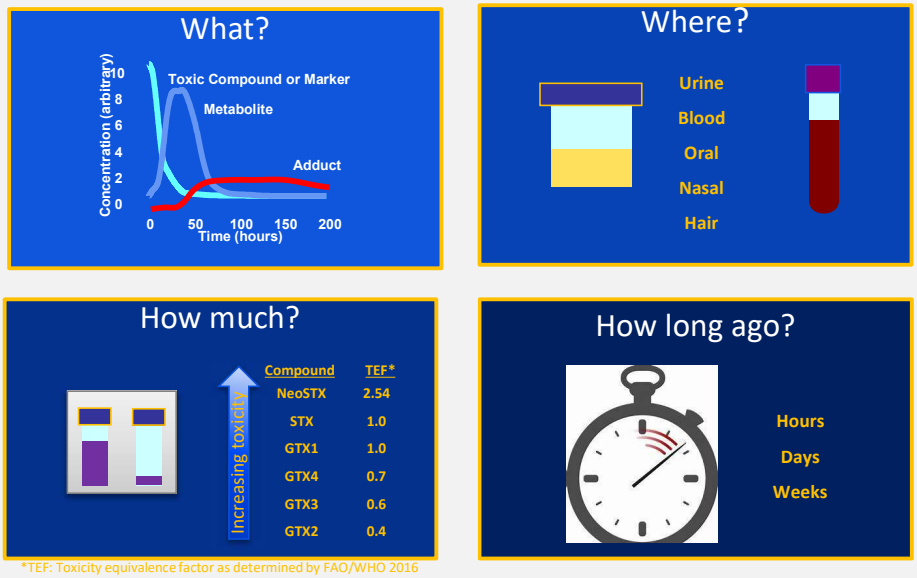
Elizabeth I. Hamelin
Division of Laboratory Sciences
Centers for Disease Control and Prevention

April 2021

CDC Emergency Response for Chemical Threats

- **Clinical sample testing**
  - Determine who was exposed
  - Identify exposure agent
  - Support emergency response
  - Determine geographical distribution
  - Evaluate long-term health effects
- **Work with State Public Health Labs**
  - Collect samples from an event
  - Distribute samples for testing
  - Ensure consistent results between labs
  - Evaluate process annually with exercises

Considerations for Toxin Exposure Detection



*TEF: Toxicity equivalence factor as determined by FAO/WHO 2016

Laboratory Testing for Toxin Exposures

- **Maintain methods to confirm exposures**
- **Develop new and improve methods**
  - Measure additional toxins and analogs
  - Detect smaller quantities
  - Improve efficiency
  - Identify new biomarkers
  - Include additional matrices
  - Enable laboratory transfer

- Saxitoxins
- Microcystins
- Brevetoxins
- Tetrodotoxin
- Domoic Acid*
- Anatoxins*

* In development

Public Health Support for Toxin Exposures

- **Study support**
  - Exposure studies
    - Microcystins, Brevetoxins
  - Animal studies
- **Response support**
  - Suspected exposures
    - Saxitoxins, Microcystins

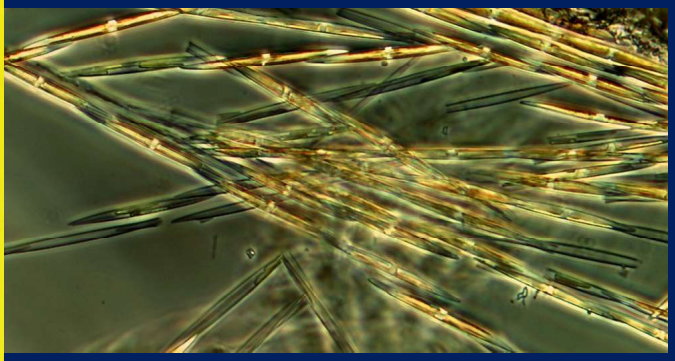
- Confirm biomarker selection
- Guide method development
- Evaluate method sensitivity
- Improve understanding

Thank you

Marine Toxins and Shellfish

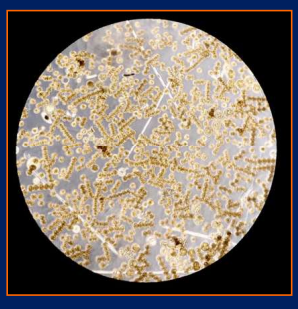
Vera L. Trainer

NOAA Northwest Fisheries Science Center, Seattle, WA



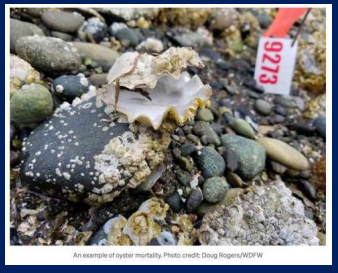
vera.l.trainer@noaa.gov

Harmful algal blooms (HABs)



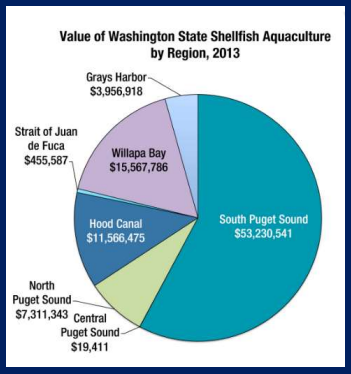
1. Toxic to humans when shellfish are eaten

2. Shellfish & fish mortality



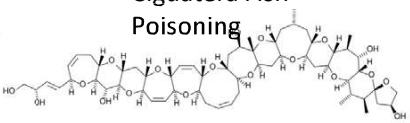
> US$100 million per year

- public health costs
- closures to fisheries harvest
- lost recreation and tourism opportunities
- monitoring and management costs



Foodborne HAB-Related Illnesses

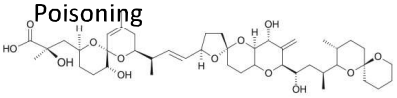
Ciguatera Fish Poisoning



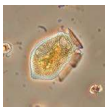
Ciguatoxins

Gambierdiscus toxicus

Diarrhetic Shellfish Poisoning

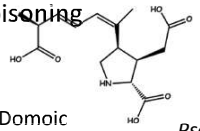


Okadaic acid

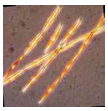


Dinophysis spp.
Prorocentrum spp.

Amnesic Shellfish Poisoning

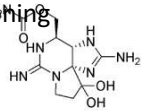


Domoic acid

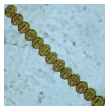


Pseudo-nitzschia spp.

Paralytic Shellfish Poisoning



Saxitoxin



Alexandrium spp.
Gymnodinium spp.
Pyrodinium spp.

Neurotoxic Shellfish Poisoning

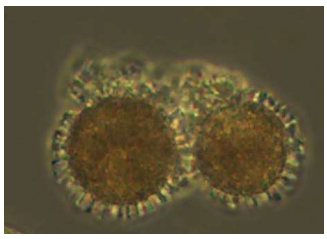
Brevetoxins

Karenia brevis

Images from Florida Fish and Wildlife Conservation Commission; NOAA CORIS; Oceanography Vol.18, No.2, June 2005: *Images courtesy* NOAA Fisheries, Seattle, WA, the Center for Integrated Marine Technology, T. Moita, and F. Figueiras .

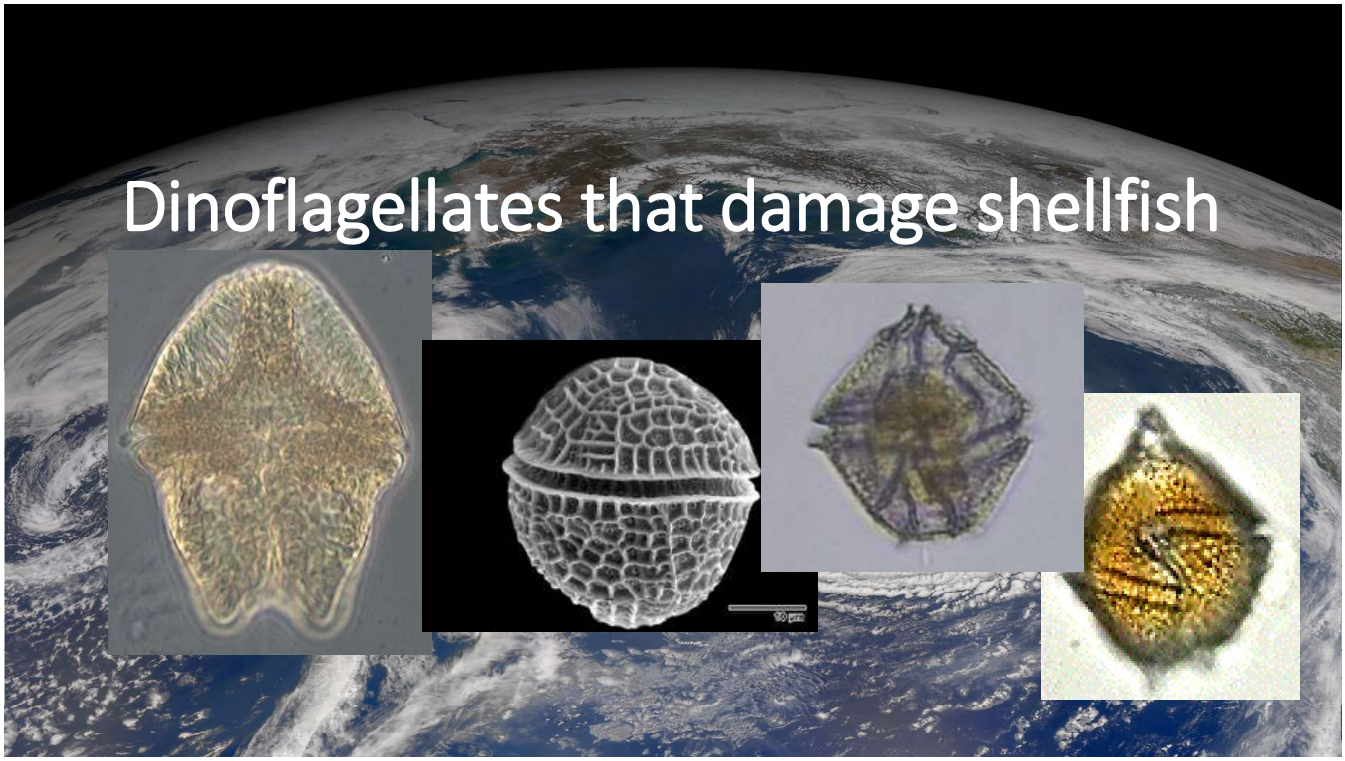
What's been causing mass shellfish die-offs around Puget Sound?

The Washington Department of Fish and Wildlife Aug 19, 2019 · 4 min read



Teri King

An example of oyster mortality. Photo credit: Doug Rogers/WDFW



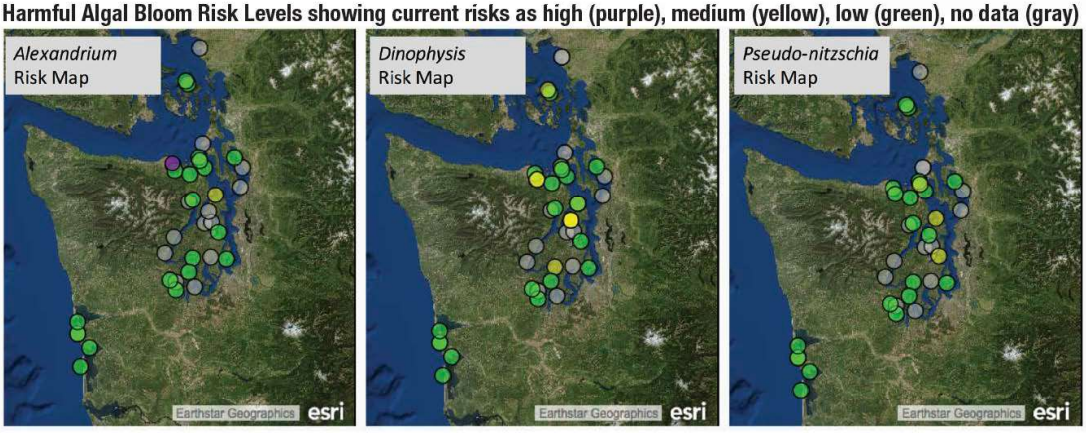
Mitigation

SOUND TOXINS

An Early Warning Program for Harmful Algal Blooms in Puget Sound

www.soundtoxins.org

Harmful Algal Bloom Risk Levels showing current risks as high (purple), medium (yellow), low (green), no data (gray)



Forecasting Harmful Algal Blooms

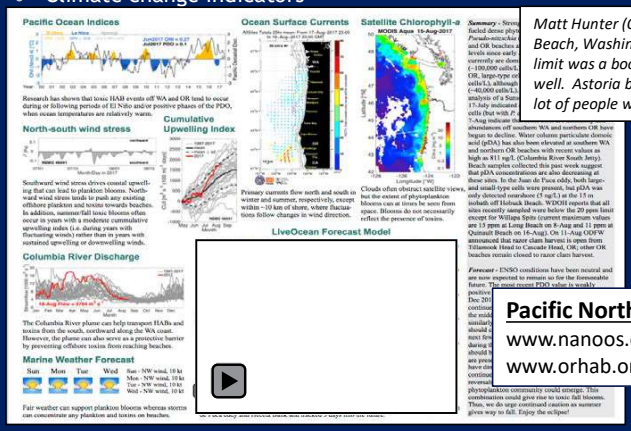
Data integration & interpretation:

- Toxin & cell monitoring at coast
- Offshore boat sampling at hotspots
- Weather predictions
- Models (cell transport & Columbia River plume)
- Climate change indicators

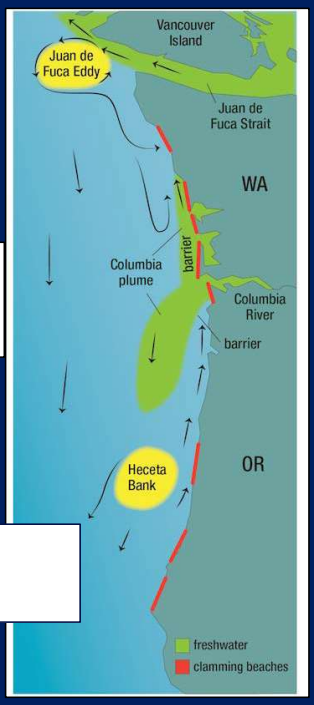
Facilitates management decisions:

Selective harvest at safe locations

Pre-emptive increase in harvest limit



Matt Hunter (ODFW) testimonial (May 2017) – "The Long Beach, Washington razor clam opening and increased bag limit was a boon for OR north coast economies as well. Astoria businesses sold a lot of digging equipment. A lot of people were hungry for clams"



Pacific Northwest HAB Bulletins
www.nanoos.org/products/habs/
www.orhab.org

HAB Preparedness & Response Workshop 2021

Impacts of Brevetoxicosis on Wildlife in Southwest Florida

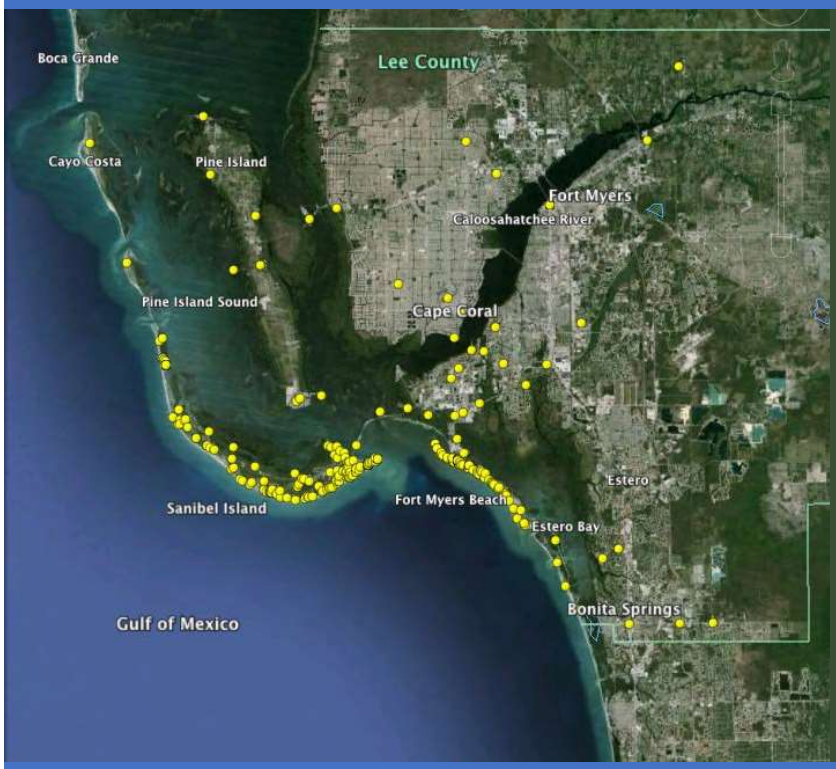
CROW
Clinic for the Rehabilitation of Wildlife
www.crowclinic.org Sanibel Island, Florida

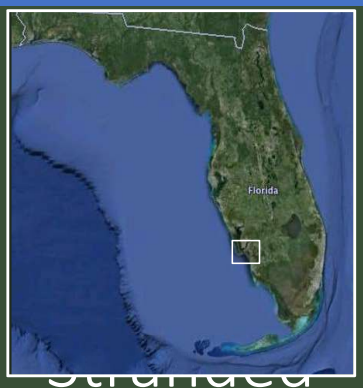
Heather W. Barron, DVM, DABVP, CertAqV

Medical & Research Director, CROW

Bathed in a Sea of Red: Annual K. Brevis blooms

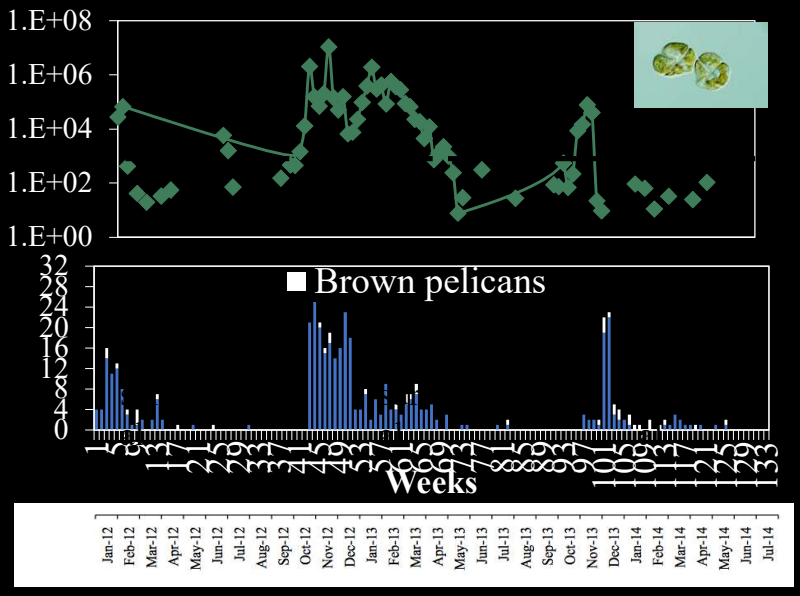
- Sanibel epicenter for FL “red tides”
- Economical & ecologic stressor
- Corresponds with large marine wildlife mortality events





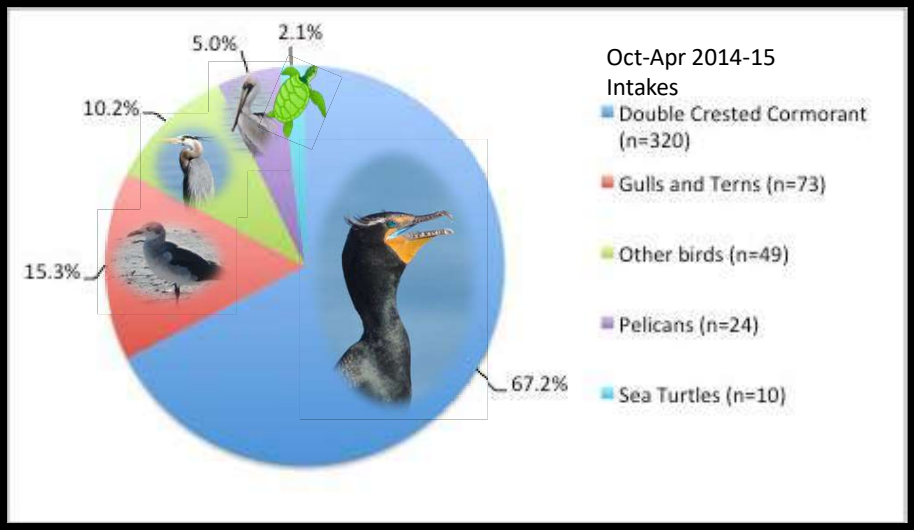
Stranded wildlife recovered from sites throughout Lee Co, FL

Wildlife can be Sentinels for Red Tides



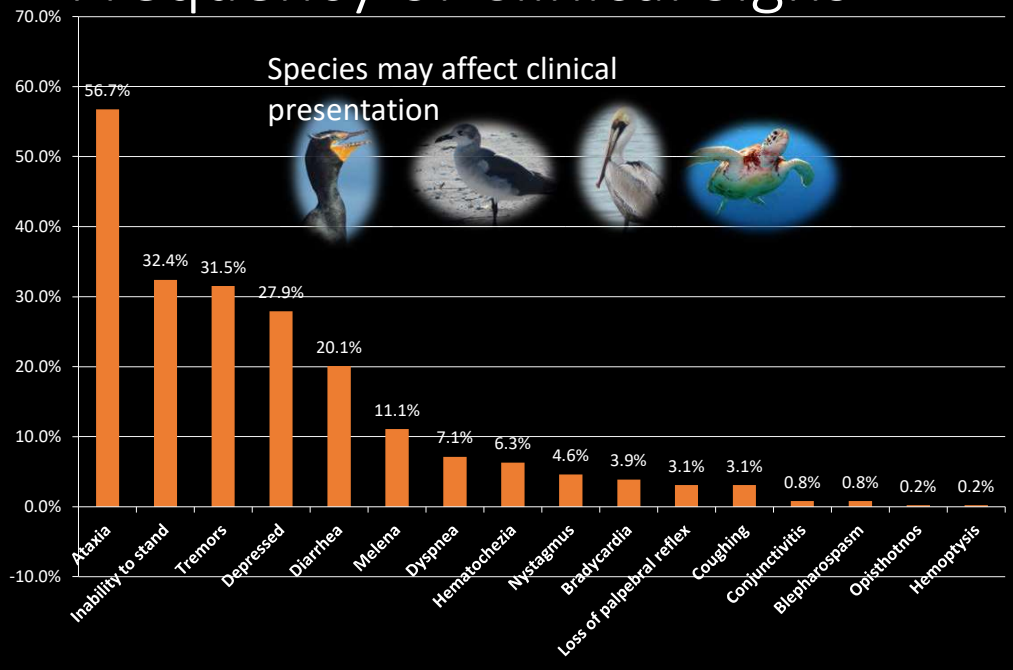
Three major red tide events can be visualized here
Increases in patients corresponded to increases in mean *K. brevis* density

Wildlife Species Commonly Affected



Predominately Immature Birds

Frequency of Clinical Signs

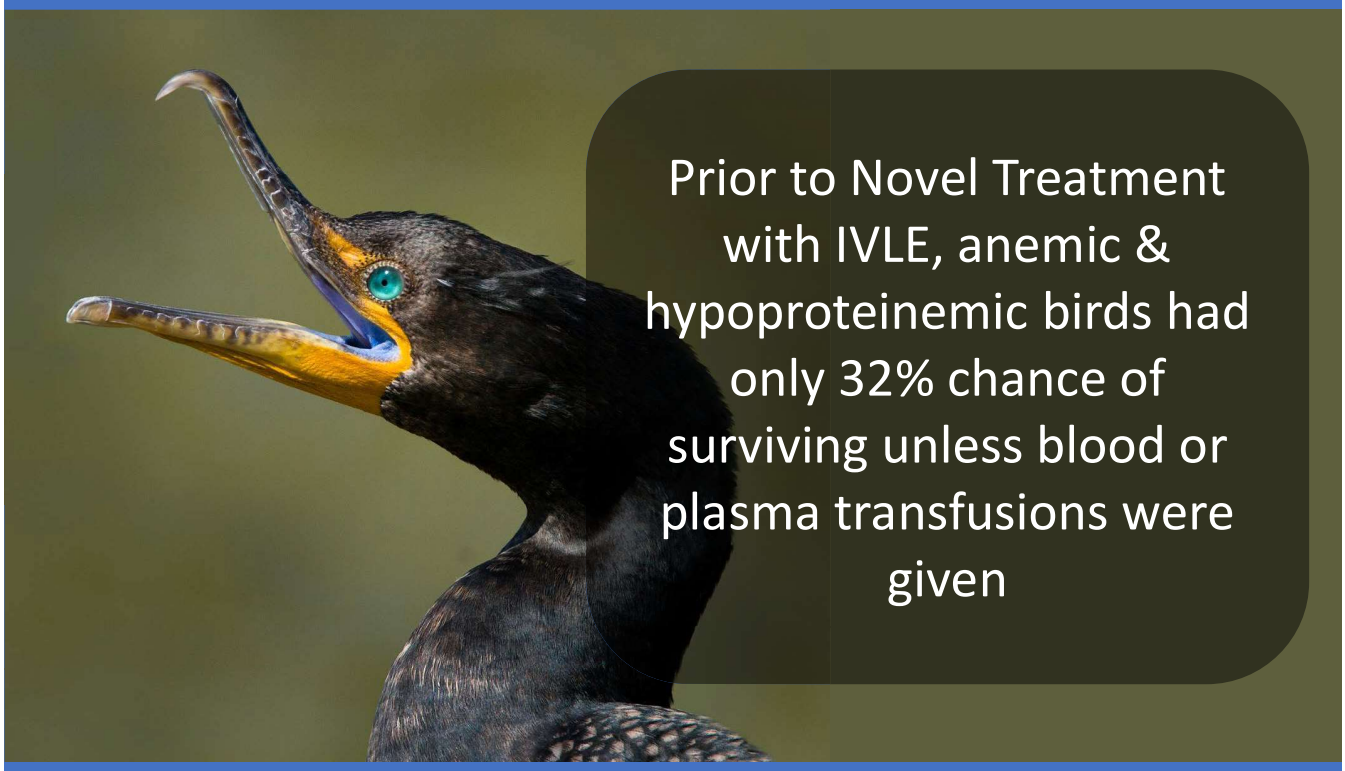


PbTx Levels in Treatment & Control Groups

- Competitive ELISA (Marbionc)
- Determine presence of PbTx in plasma samples
- Assay LOD 1 – 2 ng/ml
- FWC ran assays used in our studies
- Plasma values in birds ranged from 1 – 16.2 ng/ml & 1-93.4 in sea turtles
- Higher values obtained by serial dilutions

Other studies on brevetoxicosis at CROW:

- Total protein as a prognostic indicator for brevetoxicosis in seabirds
- Hematologic & biochemical profile changes in seabirds with brevetoxicosis
- Can blood lactate levels help guide treatment for birds suffering from brevetoxicosis?
- Establishment of activated clotting times using diatomaceous earth as a measure of coagulation in double-crested cormorants with brevetoxicosis
- Predatory Seabirds as Sentinels for Emerging Red Tide Blooms: Resolving Trophic Pathways for Brevetoxin Bioaccumulation and Rippling Food Web Impacts



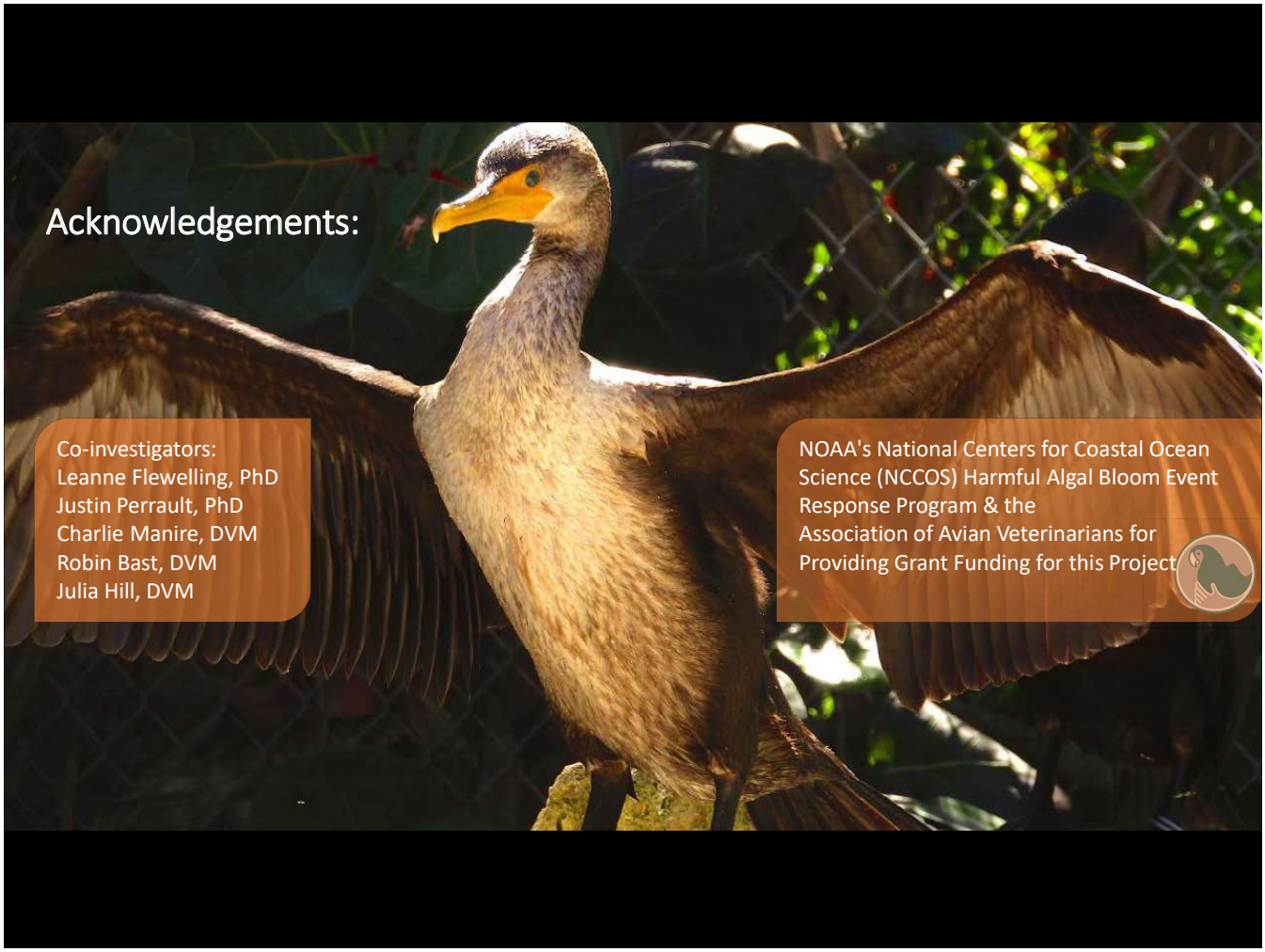
Prior to Novel Treatment with IVLE, anemic & hypoproteinemic birds had only 32% chance of surviving unless blood or plasma transfusions were given

Standard Treatment

- IV fluids based on i-STAT or profile
- Blood/plasma transfusions
- Assisted Alimentation
- GI ulcer prevention/treatment
  - Liquid diet only (D/C 24 hrs prior to whole fish to avoid obstruction)
  - Antacids (omeprazole/PPIs)
  - Sucralfate & metronidazole if melena

Results: Survival & Symptom Reduction

- 94% of sea turtles & 86% of cormorants survived to release
  - Standard/supportive care survival prior to IVLE at CROW: 62.5% in sea turtles & 55% in seabirds (25-33% reported for seabirds)
  - Most patients had significant reducation of clinical signs in a few hours and near resolution in 24 hrs



Gulf of Mexico
Red tide Respiratory Impacts

Barbara Kirkpatrick, Executive Director

Gulf of Mexico Coastal Ocean Observing System Regional Association and team

GCOOS GULF OF MEXICO COASTAL OCEAN OBSERVING SYSTEM

IOOS Integrated Ocean Observing System

Respiratory Impacts

Funding support from CDC and NIEHS

It takes a village…….

- Centers for Disease Control and Prevention
- Florida Department of Health
- Lovelace Respiratory Research Institute
- Mote Marine Laboratory
- Mount Sinai Medical Center
- Twin Cities Hospital
- University of Miami Epidemiology
- UNCW Center for Marine Science
- University of Cincinnati Biostatistics
- University of Miami Pulmonary Medicine

Public Health Message Prior to the Research

Aerosolized toxins may cause respiratory irritation- if you are uncomfortable, leave the beach and you will be OK.

Inhalation - Healthy people

One occupational exposure study done in 2001- 2002

- 5 days pre/post shift
- Symptoms
- Spirometry
- During a red tide and with no red tide

- No measured changes in pulmonary function
- Upper airway symptoms only

Inhalation - Asthmatics

Study included people over age 12 – followed over 10 years

- Toxins are a trigger for asthma
- 1 hour exposure on beach during a red tide → 5 days with increased upper and lower airway symptoms and decreased air flows
- Common asthma medications should be effective to decrease affects (tested only in animal model)
- Measured amount of brevetoxin in the air very, very small- nanograms/m^3

- Toxins travel ***at least*** 1 mile inland (again, limited studies)

So what?

- Siesta Key beach on a Saturday – 10,000 people
- ~9% of US population diagnosed with asthma
- 900 people sick for several days after a visit to a beach

Need to improve respiratory forecasts

- Temporal – toxic aerosols vary with wind speed and direction
- Spatial – previous forecasts were at county level- Sarasota has 6 public beaches
  - Blooms are most often patchy

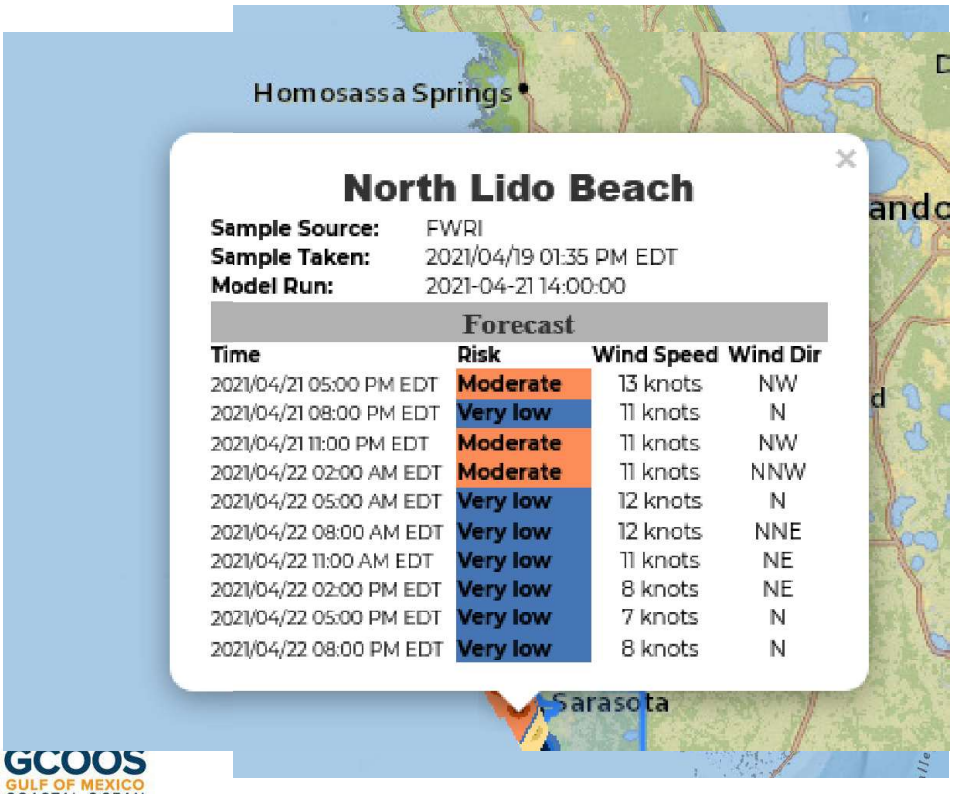
Another village…..

Funding support from NASA, NCCOS, and IOOS

New Monitoring approaches

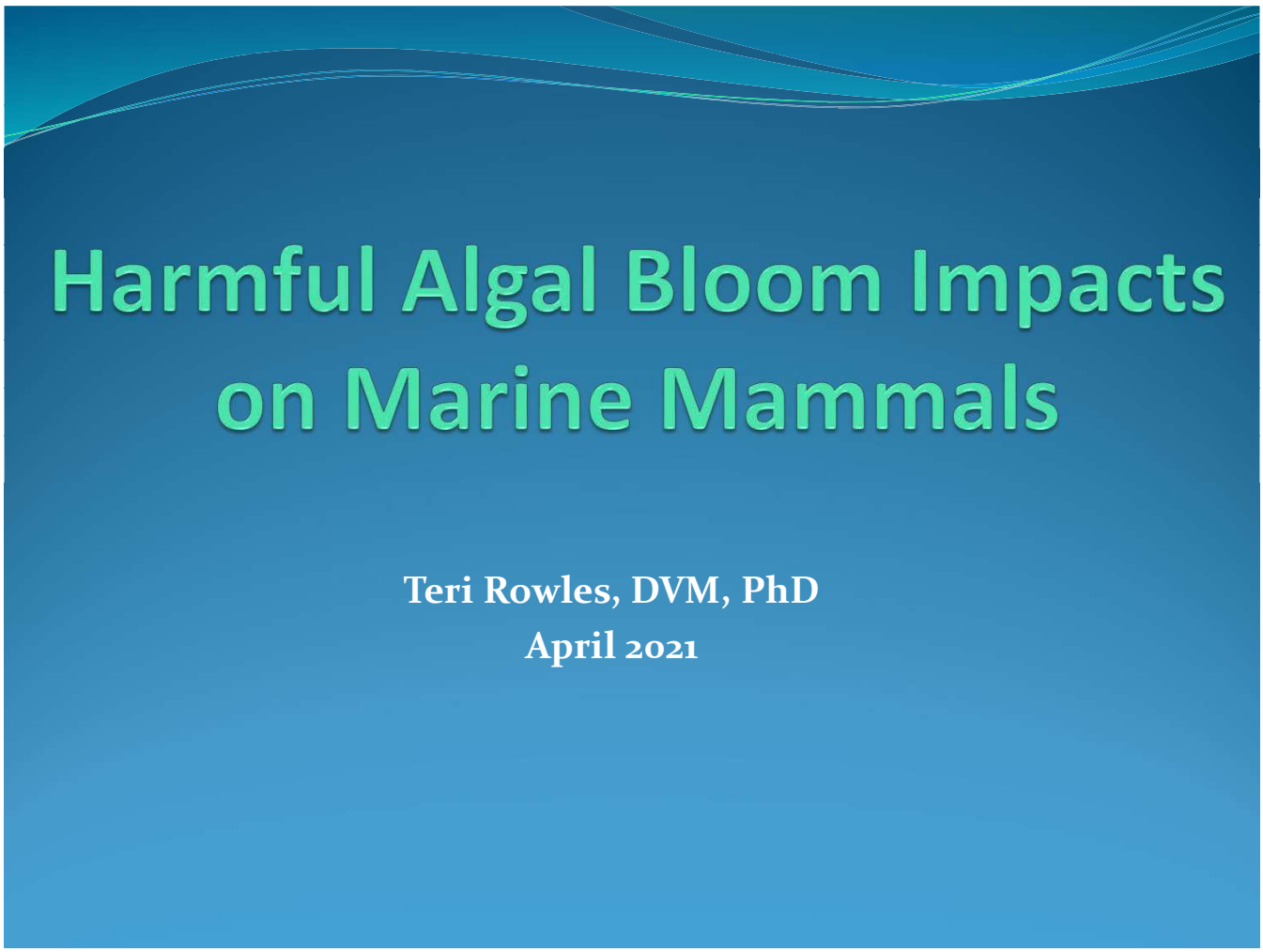
- Traditional method – highly skilled, accurate, ~15 minutes/sample
- HABscope – minimal training, less accurate- for bloom intensity. Results in several minutes by using image recognition software

https://habforecast.gcoos.org/



Thank you!

Barb.Kirkpatrick@gcoos.org

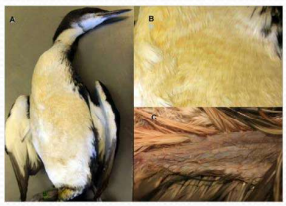


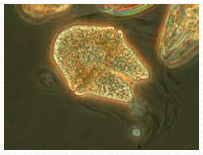
Harmful Algal Blooms- Mechanisms

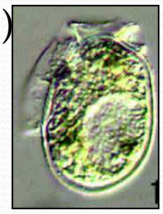
- Toxicity
- Mechanical Damage/Anoxia
- Unexpected Consequences

- Toxin Producers
  - Dinoflagellates
    - Saxitoxin (PSP)
    - Brevetoxin (NSP)
    - Ciguatoxin (CFP)
    - Okadaic Acid (DSP)
    - Yessotoxin
    - Azaspiracid
  - Diatoms
    - Domoic Acid (ASP)
  - Cyanobacteria
    - Saxitoxin
    - Microcystins

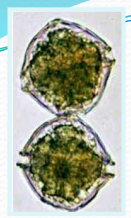
Photos: Susan Coale



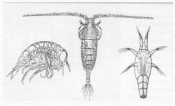




Humpback Whales Nov 1987- Jan 1988



Alexandrium tamarense



Zooplankton

- 14 whales strand in Cape Cod Bay
- STX identified in stomach contents, liver, kidney by mouse bioassay; not found by HPLC
- STX confirmed in liver, viscera of mackerel

Mackerel

Humpback Whale

Geraci et al 1989 J Fish Aq Sci
Reyero et al 1999 Nat Toxin

Multi-species Mortality Associated with Saxitoxin

- St. Lawrence Estuary, Canada; August 5 – 18 2008
  - 10 beluga, 1 fin whale
  - 8 harbour porpoise
  - 39 grey seals
  - 12 harbour seals
  - 1000 aquatic birds (loons, alcids, gannets, cormorants,)
  - invertebrates (whelks, crabs)
  - fish (capelin, sand lance, smelt, sturgeon)

Lair et al 2009 IAAAM Conf

- *Alexandrium sp.* (bloom 300 km²)
- Dx by ELISA, validated by HPLC LC/MS
- Neosaxitoxin in stomach contents, urine, bile, blood, feces, liver, kidney of birds, marine mammal, & tissues of invertebrates, fish
- HAB initiated by
  - intense freshwater runoff due to heavy rain in late July
  - warm waters
  - 2 weeks of calm winds
  - high stratification of water column

Brevetoxin – Animal Impacts

- MANATEES – FL
  - 1982, 1996, 2002, 2005 (n=308 deaths)
  - Now a repeat event
  - Toxin - ingestion, inhalation
- Clinical signs
  - Increased Respiration
  - Tremors/Lip twitching
  - Listing/unable to stay dorsal

Bossart et al 1996 Tox Path
Flewelling et al 2005 Nature

- Treatment
  - Remove from area (if inhalation)
  - Supportive care

Brevetoxin – Cetacean Impacts

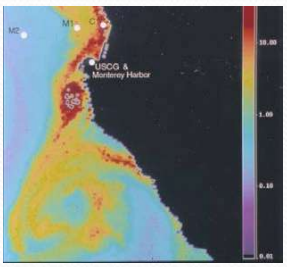
- DOLPHINS – Gulf of Mx
  - Florida 1996, 1999-2000, 2004; 2005-2006, 2018
  - Texas 2011-12
  - Toxin - ingestion
  - Acute mortalities
  - No live strandings
    - Low Brevetoxin levels in gastric, urine, feces from live free-ranging dolphins
- Panhandle FL 2004
  - 107 dead dolphins
  - 4 wk period
  - Menhaden in stomachs
    - >10-20 ,000 ng/g in fish
    - 1-10,000 ng/g in dolphin tissues

Flewelling et al 2005 Nature;
Fire et al 2007 Mar Bio
Fire et al 2008 Mar Mam Sci

Domoic Acid – Animal Impacts

- California Sea Lion Strandings
- First identified in marine mammals in 1998
- 70 sea lions stranded in Monterey Bay, 400 others died along the California coast
- Animals had altered behavior and severe seizures
- Neuronal necrosis in the hippocampus

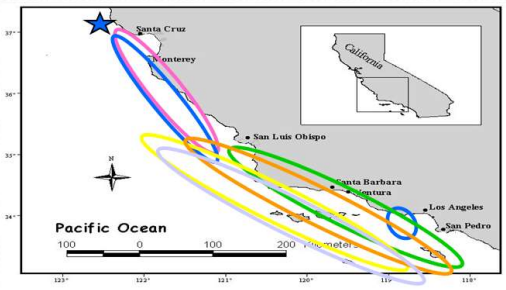
Scholin et al 2000 Nature



Domoic Acid –Animal Impacts

Marine Mammal Mortality Events

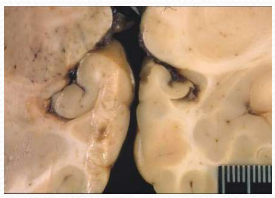
- 1998 May-Oct 81 sea lions – first report-
- 2000 May gray whale, June-July 187 sea lions, Feb-Apr sea otters
- 2002 Mar-Apr 90 dolphins, Apr-Jun >670 sea lions, Mar-Jun sea otters
- 2003 April > 100 common dolphins, May-Jun > 300 sea lions
- 2004 May-August 1000 sea lions
- 2005 May-Sept 1000 sea lions, 10 northern fur seals
- 2007 May-Oct 400 sea lions, 100 small cetaceans
- Annual cases (Acute and Chronic)

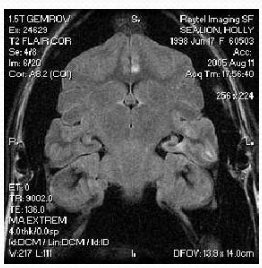


Domoic Acid – Sea Lions

- Acute Clinical Signs
  - Seizures
  - Ataxia/head weaving
  - DA in urine/feces
  - Abortions or premature parturition
- Chronic Clinical Signs
  - Stranding with seizures DA bloom absent
  - Epileptic seizures
  - Abnormal behavior
    - Aggression, abnormal stranding locations

Gulland et al 2002 Vet Record
Goldstein et al. 2008 Proc. Royal Soc. B

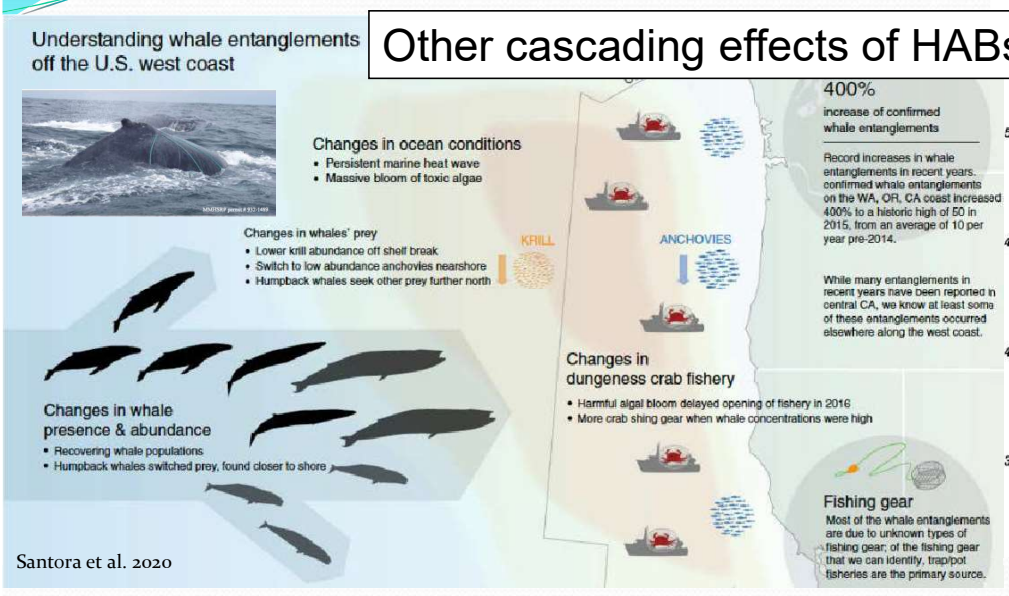




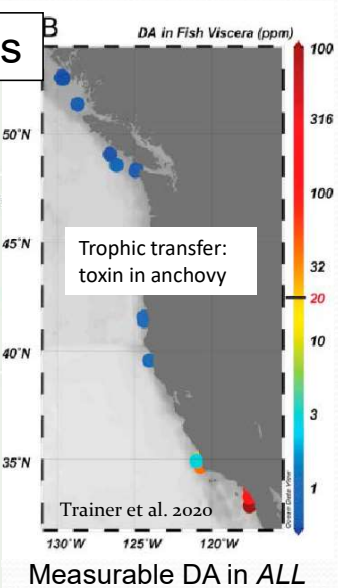
Domoic Acid–Population Level Impacts?

- Sea Lions
  - Acute mortality
  - Subclinical seizures
  - Epilepsy
  - Neuronal loss and hippocampal atrophy
  - Abortion
  - Premature parturition
  - Cardiac failure
  - Long term neurological effects

- Domoic acid crosses the placenta & accumulates in amniotic fluid
- Fetus acts as a "sink" for domoic acid
- Fetal death, abortion and premature parturition observed
- Accounts for 10% reproductive failure on rookeries



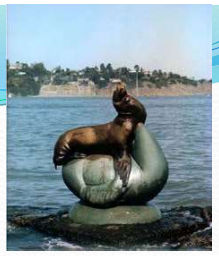
Whale entanglements



Measurable DA in *ALL* anchovy & sardine (2015)

Does high domoic acid in whale prey make entanglement more likely?

Conclusions



Algal blooms are increasing worldwide and may affect marine mammals through foodwebs, aerosals, impacts on prey, or secondary impacts of management

High levels of saxitoxin, brevetoxin & domoic acid in sea food may cause mortality and/or long term morbidity in marine mammals

Chronic effects of brevetoxin & saxitoxin on marine vertebrates are unknown

Chronic effects of domoic acid may have important ecological effects on California sea lions and other marine vertebrates, including people, beyond acute mortality events

Low levels of toxins have been found in many marine mammal species – unknown impacts of chronic low level exposure

Climate change will alter the marine environment for these species and may affect prevalence, incidence, outcome, and species affected by HABs

Partnerships for Marine Mammal UME Responses, HAB studies, and Investigations

Stranding Network Organizations and Diagnostic Partners

EPA Star Fellowship

Morris Animal Foundation

NMFS Prescott Grant Program

NOAA Marine Mammal Health and Stranding Response Program

NOAA Oceans and Human Health Initiative

Protect Wild Dolphins License Plate

Florida Fish and Wildlife Research Institute

Harmful Algal Bloom Interception, Treatment, and Transformation System (HABITATS)

Martin Page (Martin.A.Page@usace.army.mil)

Problem Statement

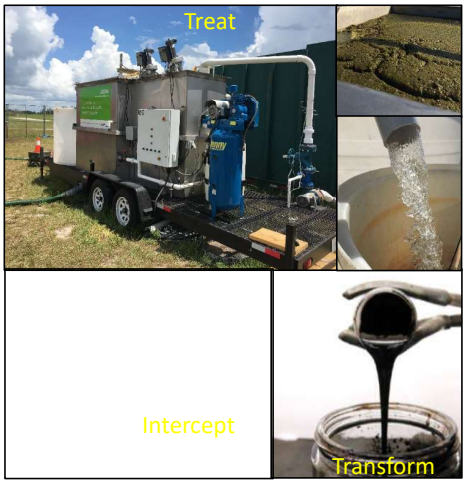
Current systems for physical removal of algae have limited scalability due to process economics and management of the large volumes of potentially toxic biomass.

Objective

Develop a deployable and scalable system for removal of freshwater HABs.

Approach

Use complementary, rapid treatment processes to remove the algae and transform it into fuel and fertilizer while destroying any potential toxins.



Research Focus Areas

The key scalability challenges being addressed by the research include:

- Chemical optimization with respect to environmental protection, dewatering, and fuel conversion.
- Development of high throughput, energy-efficient dewatering processes.
- Scaling up hydrothermal liquefaction technology for transformation of environmentally sourced algae.
- Design of efficient deployable systems for land-based and shipboard operations

ANSRP Harmful Algal Bloom Congressional Interest

HABITATS: An Integrated Three-Step HAB Removal Process

INTERCEPTION

Selectively remove algae from the water, rather than treating all the water.

TREATMENT

Clarify and oxidize the water to allow for safe discharge back into the environment, and concentrate the algae into a thick paste to minimize waste volumes.

AND

TRANSFORMATION

Recover resources from the concentrated algae while destroying any potential toxins.

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HABITATS History

- USACE was authorized to perform research on scalable solutions for prevention, detection, and control of HABs by the 2018 Water Resources Development Act.
- Baseline HABITATS experiments were performed in 2019 at Lake Okeechobee, Florida.
- Pilot scale optimization studies were performed in Florida and New York in 2020.

- **STATUS:** Commercial deployable systems can be obtained for small scale emergency response, but some waste streams need to be managed that would limit large scale deployment. The energy efficiency and throughput are not fully optimized, and associated research is ongoing.

Collaborators:

AECOM

ELASTEC

ILLINOIS SUSTAINABLE TECHNOLOGY CENTER
PRAIRIE RESEARCH INSTITUTE

Pacific Northwest NATIONAL LABORATORY

NEW YORK STATE OF OPPORTUNITY Department of Environmental Conservation

US Army Corps of Engineers®

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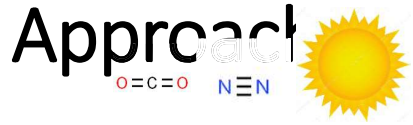
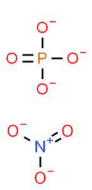
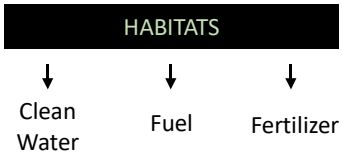
Benefits of the HABITATS Approach

- Physically remove algae as well as nutrients and toxins that are contained within the algae.
- The HABITATS process destroys cyanotoxins that may be present, both dissolved and intracellular, both in the water and the removed biomass.
- The component processes have relatively high throughput.
- The system has the potential to be energy neutral.
- Resource recovery can help offset remediation costs and enable scalability.







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- **FY20- Pilot scale validation studies of integrated system**
  - 90% removal of algae and phosphorus and 55% removal of nitrogen from water passing through the system; > 99% microcystin removal
  - Demonstrated onshore systems in Florida and New York (130 gpm)
  - Pilot tested hydrothermal liquefaction with 20% fuel yield and 99.5% microcystin destruction
  - Developed, assembled and performed preliminary testing of shipboard system
- **FY21- Increasing physical and economic scalability**
  - Research to improve algae dewatering and energy recovery
  - Developing *in-situ* flotation capability to concentrate the target
  - Executing controlled shipboard demonstration (pending, NY)
  - Acquiring the first full scale onshore HABITATS module (1500 gpm)
- **Support Needs**
  - Candidate case studies
    - Spillways, bays with HAB issues, key stakeholders
  - HAB Data
    - Algae concentrations as a function of depth
    - Economic impact and willingness to pay

First shipboard HABITATS prototype on Chautauqua Lake, NY (2020)

1500 gpm deployable dissolved air flotation system

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Projections for Full-Scale Deployable Systems

Spillway Scenario, Water Depth = 10'

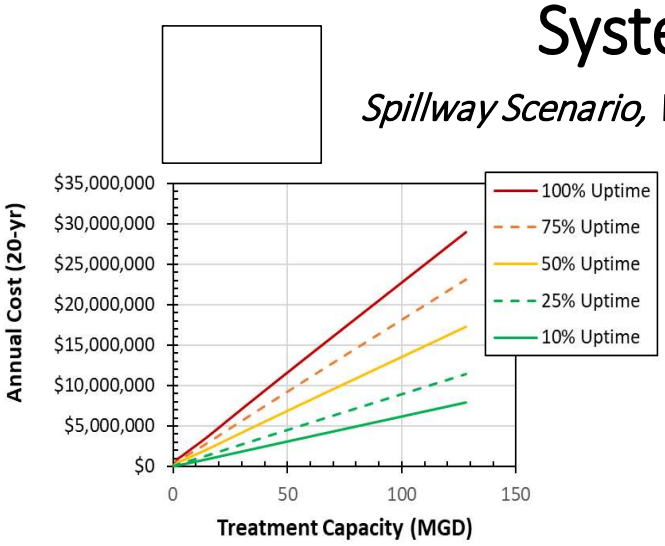


Figure 1. Projected annual cost of a HABITATS system over a 20-yr period as a function of treatment capacity with varying uptimes.

CFS = Cubic Feet per Second MGD = Million Gallons per Day

DDC is Depth-Dilution Coefficient
DDC = 0.17 → 35% of algae in upper 2' of water column
DDC = 1 → 85% of algae in upper 2' of water column

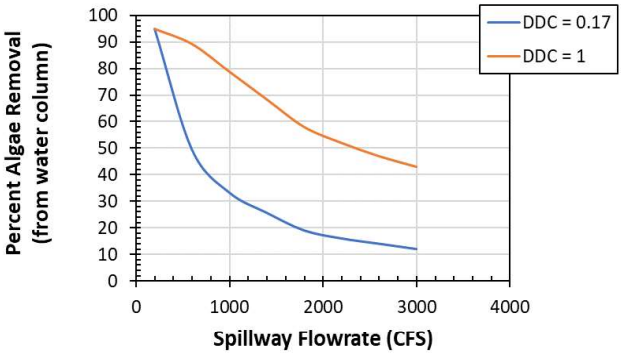


Figure 2. Effect of algae depth dilution coefficient on algae removal (from water column) by a 200 CFS (108 MGD) HABITATS system as a function of spillway flowrate.

Acknowledgements

ERDC Contacts

Project Manager	Public Affairs	Program Manager
Martin Page	Carmen Daugherty	Michael Greer
217-373-4541	573-855-2324	716-879-4229
Martin.A.Page@usace.army.mil	Carmen.S.Daugherty@usace.army.mil	Michael.J.Greer@usace.army.mil

Wrap Up

POSTER PRESENTATIONS

Step 1: Go to website (https://crrc.unh.edu/workshop/HAB)
Step 2: Scroll to "Poster Presentation" section
Step 3: Click on the poster links

Agenda: here>>

Poster Presentation

Title: *Harmful Algal Bloom indicator estimation in small inland waterbodies: Remote sensing-based software tools to assist with USACE water quality monitoring*

Authors: Molly Reif (molly.k.reif@usace.army.mil), Richard Johansen, Christina Saltus, and Erich Emery
Affiliation: U.S. Army Corps of Engineers

Title: *NCCOS Harmful Algal Bloom Forecasting Capabilities: Research to Operations*

Authors: Kaytee Pokrzywinski Boyd (kaytee.boyd@noaa.gov) and Timothy Wynne
Affiliation: National Centers for Coastal Ocean Science, NOAA

Title: NCCOS Harmful Algal Bloom Event Response Program

Authors: Mary Kate Rogener (marykate.rogener@noaa.gov)
Affiliation: NOOA National Centers for Coastal Ocean Science

THANK YOU FOR LISTENING

https://crrc.unh.edu/workshop/HAB

Coastal Response Research Center

APPENDIX C
Situation Manual

Fresh and Salty: The Story of a HAB

Situation Manual

April 29, 2021

This Situation Manual (SitMan) provides exercise participants with all the necessary tools for their roles in the exercise. Some exercise materials are intended for the exclusive use of exercise planners and facilitators, but players may view other materials that are necessary to their performance. All exercise participants may view the SitMan.

EXERCISE OVERVIEW

Exercise Name	Fresh and Salty: The Story of a HAB
Exercise Dates	April 29, 2021 from 1pm – 4pm ET/ 12pm – 3pm CT
Scope	This exercise is a virtual tabletop exercise, planned for 3 hours. Exercise play is limited to HABs exercise invitees only.
Mission Area(s)	Response & Recovery
Core Capabilities	Information & Intelligence; Environmental Response; Operational Assistance
Objectives	1. Discuss each represented agency's resources, expertise, capabilities, roles, and responsibilities related to a cyanoHAB event. 2. Discuss and evaluate current plans, policies, and procedures in-place to effectively manage a cross-agency, coordinated response.
Threat or Hazard	Toxic Cyanobacteria Bloom
Scenario	As a result of excess freshwater into the San Jacinto and Trinity rivers from a Cat 4 hurricane, a toxic cyanobacterial bloom (cyanoHAB) event occurs in Galveston Bay and then moves into the Gulf of Mexico.
Sponsor	NOAA OR&R Disaster Preparedness Program (DPP) & the University of New Hampshire's Coastal Response Research Center (CRRC)
Participating Organizations	NOAA, CDC, EPA, FDA, FWC, LA DEQ, LA DH, MS DMR, TPWD, USACE, USGS, State Shellfish Control Authority
Point of Contact	Katie Krushinski, Emergency Management Specialist, NOAA OR&R Disaster Preparedness Program (DPP), 7344 Zeigler Blvd., Mobile, AL 36608, (251) 234-1734

GENERAL INFORMATION

Exercise Objectives and Core Capabilities

The following exercise objectives in Table 1 describe the objectives for the exercise. The objectives are linked to core capabilities, which are distinct critical elements necessary to achieve the specific mission area(s). The selection of objectives and aligned core capabilities are guided by real events as well as agency and regional needs.

Exercise Objective	Core Capability
1. Discuss each represented agency's resources, expertise, capabilities, roles, and responsibilities related to a cyanoHAB event.	Environmental Response
2. Discuss and evaluate current plans, policies, and procedures in-place to effectively manage a cross-agency, coordinated response.	Operational Assistance; Information & Intelligence

Table 1. Exercise Objectives and Associated Core Capabilities

Participant Roles and Responsibilities

The term *participant* encompasses many groups of people, not just those playing in the exercise. Groups of participants involved in the exercise, and their respective roles and responsibilities, are as follows:

- **Players.** Players are those who have an active role in discussing their regular roles and responsibilities during the exercise. Players discuss or initiate actions in response to the simulated emergency.
- **Facilitators.** Facilitators provide situation updates and moderate discussions. They also provide additional information or resolve questions as required.
- **Note Takers.** These individuals are assigned to breakout groups to capture discussions related to each of the exercise modules.

Exercise Structure

This exercise will be a multimedia, facilitated exercise. Players will participate in the following two (2) modules:

- Module 1: Freshwater Response
- Module 2: Freshwater to Marine Response

Each module begins with an update that summarizes key events occurring within that time period. After the updates, participants review the situation and engage in group discussions to answer event-related questions. Then, participants will engage in a facilitated report-out discussion in which a spokesperson from each group will present a synopsis of the group's responses, priorities, and recommendations.

Exercise Guidelines

- This exercise will be held in an open, low-stress, no-fault environment. Varying viewpoints, even disagreements, are expected.
- Respond to the scenario using your knowledge of current plans and capabilities (i.e., you may use only existing assets) and insights derived from your training.
- Decisions are not precedent setting and may not reflect your organization's final position on a given issue. This exercise is an opportunity to discuss and present multiple options and possible solutions.
- Issue identification is not as valuable as suggestions and recommended actions that could improve response efforts. Problem-solving efforts should be the focus.

Exercise Assumptions and Artificialities

In any exercise, assumptions and artificialities may be necessary to complete play in the time allotted and/or account for logistical limitations. Exercise participants should accept that assumptions and artificialities are inherent in any exercise and should not allow these considerations to negatively impact their participation. During this exercise, the following apply:

- The exercise is conducted in a no-fault learning environment wherein capabilities, plans, systems, and processes will be evaluated.
- The exercise scenario is plausible, and events occur as they are presented.
- All players receive information at the same time.

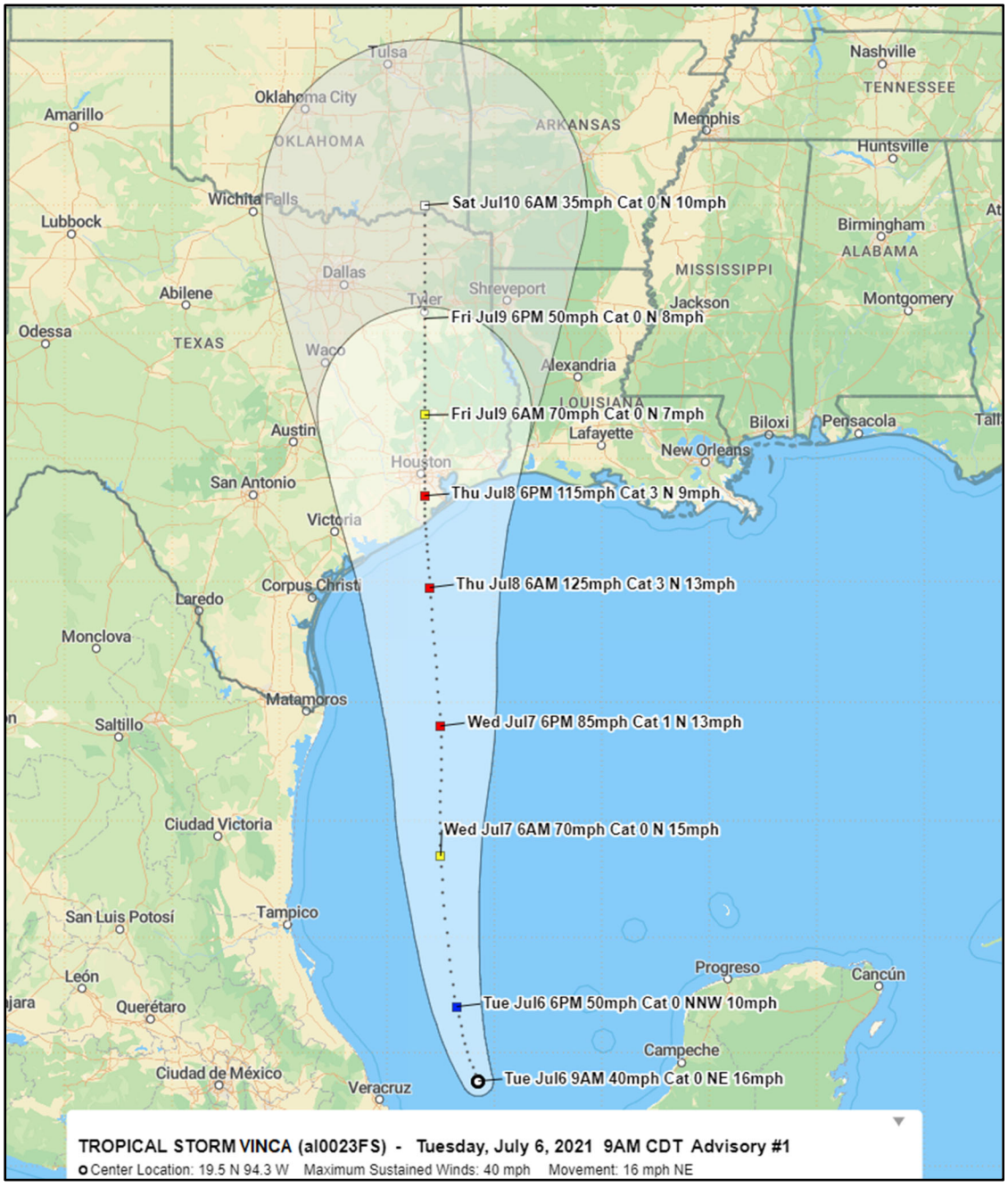
Exercise Evaluation

Evaluation of the exercise is based on the exercise objectives and aligned capabilities, which are documented in this Situation Manual (SitMan). Facilitators will help assess these capabilities based on exercise play. Additionally, players will be asked to complete participant feedback forms. These documents, coupled with Facilitator observations and notes, will be used to evaluate the exercise and compile the After-Action Report (AAR).

INCIDENT BACKGROUND

Tuesday (7/6/21):

On July 6, 2021, Tropical Storm Vinca was located in the Bay of Campeche. Tropical Storm Vinca is currently moving northeast at 16 mph. Over the next few days, this storm is expected to strengthen into a major hurricane producing strong winds and large amounts of rain as it approaches and makes landfall along the Texas coast.



Wednesday (7/7/21)

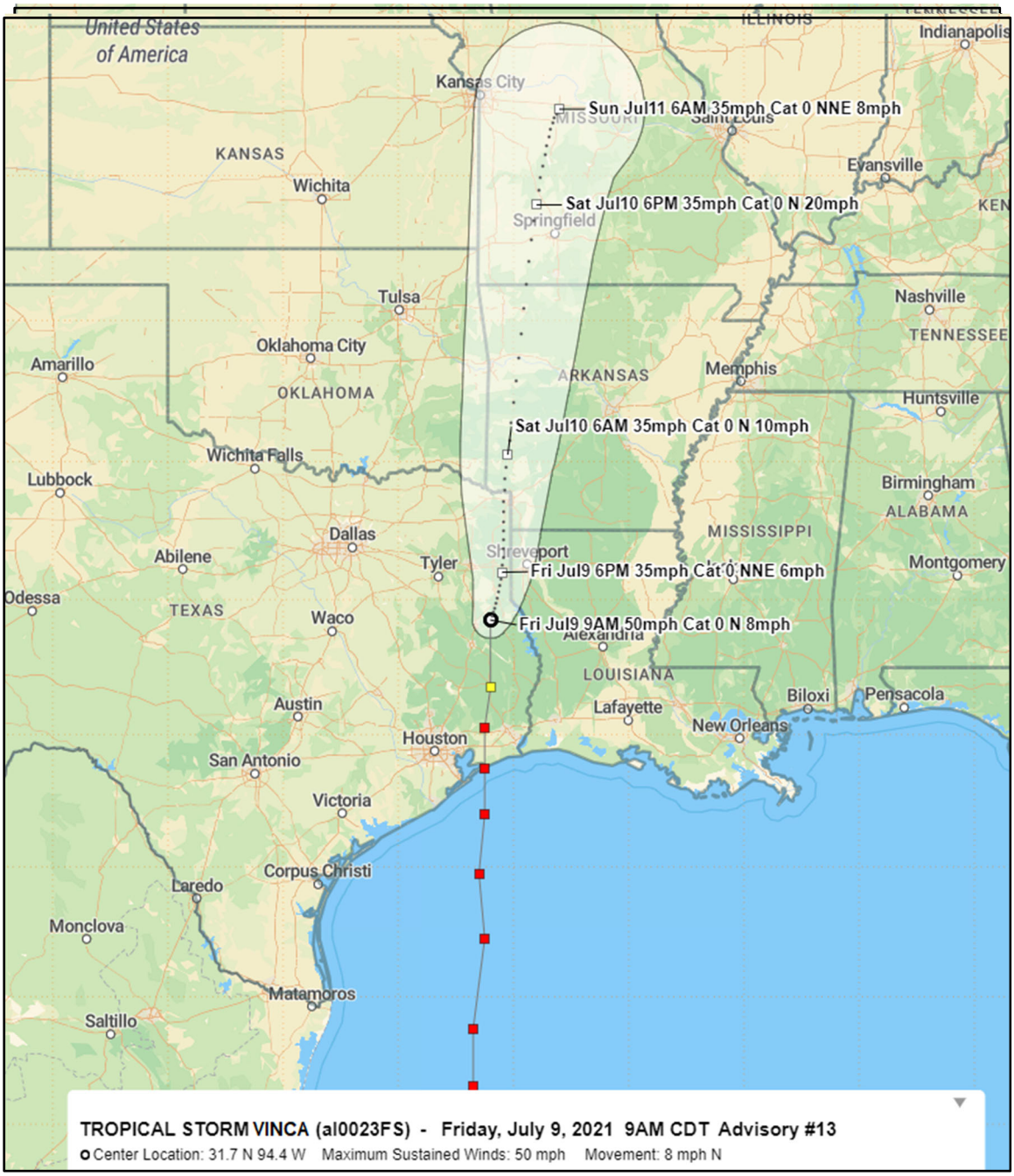
On July 7, 2021, Hurricane Vinca, a Category 1 hurricane, was located approximately 130 miles south southeast of San Padre Island, Texas, moving north-northwest at 10 mph. The storm is projected to continue to strengthen over roughly the next 36 hours. If Vinca stays on the current path, she is expected to make landfall as a major hurricane in the Galveston, Texas area during the evening of July 8.

Thursday (7/8/21)

As of 0900 CT, Hurricane Vinca has increased in intensity and is now a Category 4 hurricane. Vinca is moving north-northwest at 8 mph. As she moves closer to landfall along the Texas coast, heavy rains and strong winds will continue. The amount of rain expected will likely push the San Jacinto and Trinity rivers close to, if not past, flood stage.

Friday (7/9/21)

Hurricane Vinca made landfall along the Texas coast near Galveston at 1815 (6:15 CT) Thursday evening as a Category 4 storm. As Vinca moves out of Texas, she will continue to produce heavy rains and strong winds throughout the remainder of tonight. Vinca will continue to slowly (at



approximately 10 mph) move out of the Texas area throughout the day and will move through the Midwest over the weekend.

MODULE 1: FRESHWATER RESPONSE

Scenario

Hurricane Vinca made landfall in the Galveston, Texas region as expected on Thursday, July 9, 2021.

In addition to hurricane-related impacts, the storm created excess freshwater, which flowed into Galveston Bay from the San Jacinto and Trinity Rivers. This excess freshwater introduced nutrients and dropped the salinity from 15 psu to 0 psu over a one and a half day period in the upper portions of the bay. This stimulated a cyanobacterial bloom in the northeast portion of the Galveston Bay, at the mouth of the Trinity River. This river is known to have high abundance of cyanobacteria, occasionally including species that produce toxins. Preliminary field results investigating the bloom composition confirmed the abundance of cyanobacterial species known to produce a variety of cyanobacteria toxins. A dog death from exposure to the cyanobacterial bloom was reported, which garnered national press coverage and an increase in calls from the public to the Texas Department of State Health Services and Texas Department of Environmental Quality. The dog was exposed to cyanotoxins near an oyster growing area in the Bay.

Key Issues

- The excess freshwater introduced nutrients and dropped salinity in the upper portions of the bay.
- The drop in salinity and increase in nutrients stimulated a wide spread cyanobacterial bloom in Galveston Bay.
- Preliminary results confirmed the abundance of cyanobacterial species in the water.

Questions

Based on the information provided, participate in the discussion concerning the issues raised in Module 1.

1. Which agency(ies) should be communicating/coordinating to respond to the cyanobacterial bloom in Galveston Bay? Which agencies should respond to the dog death?
2. Does your agency have a process/plan/procedure in-place to respond to a cyanoHAB event in a freshwater water bodies? If yes, what does the process/plan/procedure cover (or address)?
3. What agencies provide science-based information related to the cyanoHAB event in a freshwater environment that could be used to help decision-makers? What type of information is provided?

MODULE 2: FRESHWATER TO MARINE RESPONSE

Scenario

The cyanobacterial bloom that initially developed in the northeast portion of the Bay, at the mouth of the Trinity River, continued southward through Galveston Bay toward the Gulf of Mexico, where it persisted. Preliminary field data confirmed the abundance of cyanobacterial species known to produce a variety of toxins. Further monitoring in the Gulf of Mexico observed hypoxia and accounted the death of oysters, dolphins, sea turtles, and fish.

Key Issues

- The cyanobacterial bloom moved southward into the Gulf of Mexico.
- Preliminary results confirmed the abundance of toxic-producing cyanobacterial species in Galveston Bay and the Gulf of Mexico.
- This resulted in hypoxia and mortalities of oysters, sea turtles, and other estuarine and marine species.

Questions

Based on the information provided, participate in the discussion concerning the issues raised in Module 2.

1. Which agency(ies) should be communicating/coordinating to respond to the cyanobacterial bloom in the Gulf of Mexico?
2. Does your agency have a process/plan/procedure in-place to respond to a cyanoHAB event in a marine environment? If yes, what does the process/plan/procedure cover (or address)?
3. What agencies provide science-based information related to the cyanoHAB event in a marine environment that could be used to help decision-makers? What type of information is provided?

APPENDIX A: EXERCISE SCHEDULE

Time	Personnel	Activity
Thursday, April 29, 2021		
1200-1300	Exercise Team	Last Minute Setup & Logistics
1300-1310	All Participants & Exercise Team	Welcome & Opening Remarks
1310-1330	All Participants & Exercise Team	Exercise Overview & Agenda
1330-1335	All Participants & Exercise Team	Module 1: Situation Brief
1335-1405	All Participants & Exercise Team	Module 1: Freshwater Response
1405-1425	All Participants & Exercise Team	Module 1: Group Debrief
1425-1435	**BREAK**	
1435-1440	All Participants & Exercise Team	Module 2: Situation Brief
1440-1510	All Participants & Exercise Team	Module 2: Freshwater to Marine Response
1510-1530	All Participants & Exercise Team	Module 2: Group Debrief
1530-1600	All Participants & Exercise Team	Hotwash
1600	**END EX**	
1600-1630	All Participants & Exercise Team	Wrap-up & Final Comments

APPENDIX B: EXERCISE PARTICIPANTS

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APPENDIX C: ACRONYMS

Acronym	Term
AAR	After Action Report
CDC	Centers for Disease Control and Prevention
CRRC	Coastal Response Research Center
CT	Central Time
DPP	Disaster Preparedness Program
EPA	Environmental Protection Agency
FDA	Food and Drug Administration
FEMA	Federal Emergency Management Agency
FWC	Fish and Wildlife Conservation Commission
HAB	Harmful Algal Bloom
LA DEQ	Louisiana Department of Environmental Quality
LA DH	Louisiana Department of Health
MPH	Miles Per Hour
MS DMR	Mississippi Department of Marine Resources
NCCOS	National Centers for Coastal Ocean Science
NESDIS	National Environmental Satellite, Data, and Information Service
NOAA	National Oceanic and Atmospheric Administration
OR&R	Office of Response & Restoration
PSU	Practical Salinity Unit
SEFSC	Southeast Fisheries Science Center
SitMan	Situation Manual
TPWD	Texas Parks and Wildlife Department
USACE	United States Army Corp of Engineers
USGS	United States Geological Survey

APPENDIX D
After-Action Report

Fresh and Salty: The Story of a HAB

After-Action Report/Improvement Plan

July 28, 2021

The After-Action Report/Improvement Plan (AAR/IP) aligns exercise objectives with preparedness doctrine to include the National Preparedness Goal and related frameworks and guidance. Exercise information required for preparedness reporting and trend analysis is included.

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EXERCISE OVERVIEW

Exercise Name	Fresh and Salty: The Story of a HAB
Exercise Date	April 29, 2021 from 1pm – 4pm ET/12pm – 3pm CT
Scope	This exercise is a virtual tabletop exercise, planned for 3 hours. Exercise play is limited to HABs exercise invitees only
Mission Area(s)	Response & Recovery
Core Capabilities	Information & Intelligence; Environmental Response; Operational Assistance
Objectives	1. Discuss each represented agency's resources, expertise, capabilities, roles, and responsibilities related to a cyanoHAB event. 2. Discuss and evaluate current plans, policies, and procedures in-place to effectively manage a cross-agency, coordinated response.
Threat or Hazard	Toxic Cyanobacterial Bloom
Scenario	As a result of excess freshwater into the San Jacinto and Trinity rivers from a Cat 4 hurricane, a toxic cyanobacterial bloom (cyanoHAB) event occurs in Galveston Bay and then moves into the Gulf of Mexico.
Sponsor	NOAA OR&R Disaster Preparedness Program (DPP) & the University of New Hampshire's Coastal Response Research Center (CRRC)
Participating Organizations	NOAA, CDC, EPA, FDA, FWC, LA DEQ, LA DH, MS DMR, TPWD, USACE, USGS, representative State Shellfish Control Authorities
Point of Contact	Katie Krushinski, Emergency Management Specialist, NOAA OR&R Disaster Preparedness Program (DPP), 7344 Zeigler Blvd., Mobile, AL 36608, (251) 234-1734

ANALYSIS OF CORE CAPABILITIES & OBJECTIVES

Aligning exercise objectives and core capabilities provides a consistent taxonomy for evaluation that transcends individual exercises to support preparedness reporting and trend analysis. Table 1 includes the exercise objectives, aligned core capabilities, and performance ratings for each core capability as observed during the exercise and determined by the evaluation team.

Core Capability	Objective	Performed without Challenges (P)	Performed with Some Challenges (S)	Performed with Major Challenges (M)	Unable to be Performed (U)
Information & Intelligence	Discuss and evaluate current plans, policies, and procedures in-place to effectively manage a cross-agency, coordinated response.		✓		
Environmental Response	Discuss each represented agency's resources, expertise, capabilities, roles, and responsibilities related to a cyanoHAB event.		✓		
Operational Assistance	Discuss each represented agency's resources, expertise, capabilities, roles, and responsibilities related to a cyanoHAB event.		✓		

Table 1. Summary of Core Capability Performance

Ratings Definitions:

- Performed without Challenges: The targets and critical tasks associated with the core capability were completed in a manner that achieved the objective(s) and did not negatively impact the performance of other activities. Performance of this activity did not contribute to additional health and/or safety risks for the public or for emergency workers, and it was conducted in accordance with applicable plans, policies, procedures, regulations, and laws.
- Performed with Some Challenges: The targets and critical tasks associated with the core capability were completed in a manner that achieved the objective(s) and did not negatively impact the performance of other activities. Performance of this activity did not contribute to additional health and/or safety risks for the public or for emergency workers, and it was conducted in accordance with applicable plans, policies, procedures, regulations, and laws. However, opportunities to enhance effectiveness and/or efficiency were identified.
- Performed with Major Challenges: The targets and critical tasks associated with the core capability were completed in a manner that achieved the objective(s), but some or all of the following were observed: demonstrated performance had a negative impact on the performance of other activities; contributed to health and/or safety risks for the public or for emergency workers; and/or was not conducted in accordance with applicable plans, policies, procedures, regulations, and laws.
- Unable to be Performed: The targets and critical tasks associated with the core capability were not performed in a manner that achieved the objective(s).

Note: *The following information provides an overview of the performance related to each objective of this exercise. Additional recommendations related to the workshop can be found in the "Proceedings of the Harmful Algal Bloom (HAB) Preparedness & Response" document.*

Objective 1: Discuss each represented agency's resources, expertise, capabilities, roles, and responsibilities related to a cyanoHAB event.

The strengths and areas for improvement for each objective are described in this section.

Strengths

The partial capability level can be attributed to the following strengths:

Strength 1: Representatives from each of the agencies that would be involved in a cyanoHABs event were present during the exercise and effectively shared their agency's resources, expertise, capabilities, roles, and responsibilities.

Strength 2: Many of the participating agencies have resources, expertise, capabilities, roles, and responsibilities related to a specific area or areas of the cyanoHAB response – typically not the overall response itself.

Areas for Improvement

The following areas require improvement to achieve the full capability level:

Area for Improvement 1: Due to various factors, not all of the Gulf of Mexico entities that are involved in a cyanoHAB event were present at the exercise, which resulted in some uncertainty related to the resources, capabilities, roles, and responsibilities of Gulf of Mexico cyanoHABs response entities during an event.

Area for Improvement 2: Through exercise discussion, some participating agencies explained they could provide resources to the response, but either do not have a mandate or would require states to request assistance prior to being involved, for example.

Objective 2: Discuss and evaluate current plans, policies, and procedures in-place to effectively manage a cross-agency, coordinated response.

The strengths and areas for improvement for each objective are described in this section.

Strengths

The partial capability level can be attributed to the following strengths:

Strength 1: Many of the agencies involved in both the freshwater and the marine response have some sort of plan, policy, and/or procedure in-place to assist in a cross-agency, coordinated response.

Strength 2: Some Gulf States have plans, policies, and procedures in-place to manage a cross-agency, coordinated response.

Areas for Improvement

The following areas require improvement to achieve the full capability level:

Area for Improvement 1: Although there are current plans, policies, and procedures in-place, exercise participants discussed the fact that many of these are focused on one aspect of the response rather than the overall, coordinated effort and how that process works. This makes a coordinated and comprehensive response challenging.

Area for Improvement 2: Through group discussions, it became clear that there is a need for coordinated response efforts between and within federal and state agencies.

Area for Improvement 3: It appears as if the cyanoHABs response entities in the Gulf have communication barriers related to the sharing of regional cyanoHABs plans, policies, and/or procedures.

APPENDIX A: IMPROVEMENT PLAN

This Improvement Plan (IP) has been developed specifically for the Interagency Working Group for HABHRCA (IWG-HABHRCA) and those who participated in the tabletop exercise Fresh and Salty: The Story of a HAB, conducted on April 29, 2021[1].

Objective	Issue/Area for Improvement	Corrective Action	Primary Responsible Organization	Organization POC	Start Date	Completion Date
Discuss each represented agency's resources, expertise, capabilities, roles, and responsibilities related to a cyanoHAB event.	1. Some uncertainty related to the resources, expertise, capabilities, roles, & responsibilities of Gulf of Mexico cyanoHAB response entities during an event.	A. Consider determining POC(s) for each Gulf state related to cyanoHABs events and create documentation (one-pager, etc.) outlining their abilities.				
		B. Research/develop state-by-state list of POC(s) for a cyanoHAB event ensuring pre-event coordination & relationships are developed & maintained.				
		C. Consider development of regional groups designed to foster pre-event relationships & coordinate efforts related to cyanoHABs events.				
	2. Some participating agencies are able to provide resources to the response, however they do not have a mandate to do so or they would require state's request prior to involvement.	A. Explore aspects of a cyanoHAB event related to involved agencies & consider if new mandates are appropriate to help support response efforts. *The IWG (or HAB response community) could explore, including potential engagements with FEMA.*				

[1] The identified Areas for Improvement and associated Corrective Actions are designed specifically for the Gulf of Mexico region, but may be relevant to other areas where HABs events occur.

		B. If not already done, clearly outline the state's process to obtain outside agency support during a cyanoHAB event. Ensure each Gulf state is aware of this process & socialize.				

Objective	Issue/Area for Improvement	Corrective Action	Primary Responsible Organization	Organization POC	Start Date	Completion Date
Discuss and evaluate current plans, policies, and procedures in-place to effectively manage a cross-agency, coordinated response.	1. Many plans, policies, & procedures currently in-place focus on one aspect of event making a coordinated and comprehensive response challenging.	A. Explore the option & ability to coordinate cross-agency guidelines for plans, policies, & procedures related to cyanoHAB events.				
		B. Alternatively, determine one-stop-location for collection of involved agency plans, policies, procedures related to cyanoHABs events.				
	2. Need for coordinated response efforts between and within federal and state agencies.	A. Create cross-Gulf coordinating body to help develop state plan, policy, & procedure guidelines in an effort to create coordination & consistency.				
		B. Consider Gulf-wide engagement with planning and research groups such as the Gulf of Mexico Alliance, Gulf of Mexico Coastal Ocean Observing System (GCOOS), Northern Gulf Institute, etc. to enhance cyanoHABs coordination and response efforts.				
		C. Consider creating (or implementing) a cyanoHAB response plan, policy, procedure template which would allow all states (Gulf & beyond) to fill in the areas that are applicable to their response roles and capabilities.				

	3. It appears as if cyanoHABs response entities in the Gulf are not communicating and sharing the status of their plans, policies, and/or procedures related to cyanoHABs events.	A. Determine feasibility to pull together state POCs to effectively share information, ideas, & progression of each state's plans, policies, &procedures.				
		B. Develop regional housing location for response plans, policies, & procedures (state & federal) allowing for quick access (could be protected, if needed).				

Objective	Issue/Area for Improvement	Corrective Action	Primary Responsible Organization	Organization POC	Start Date	Completion Date
Misc.: Communication	1. No formal process mentioned related to science agencies sharing information during cyanoHAB event.	A. Create cross-agency team to ensure science-related cyanoHABs information is effectively shared with stakeholders.				
	2. Lack of formal process and guidelines for sharing cyanoHABs information.	A. Determine communications-related POCs for cyanoHABs events & create coordinating body to ensure consistent message is shared.				
		B. Explore possibility of cross-agency communications team to create template for information that is shared with the public.				
	3. Uncertainty of communications process for sharing critical response information with stakeholders (outside of the science information).	A. Determine ways to share & socialize cyanoHABs process with states & other entities (e.g., who is involved; when is it time to call for assistance; what funding is available & how to apply/request; etc.).				

APPENDIX B: EXERCISE PARTICIPANTS

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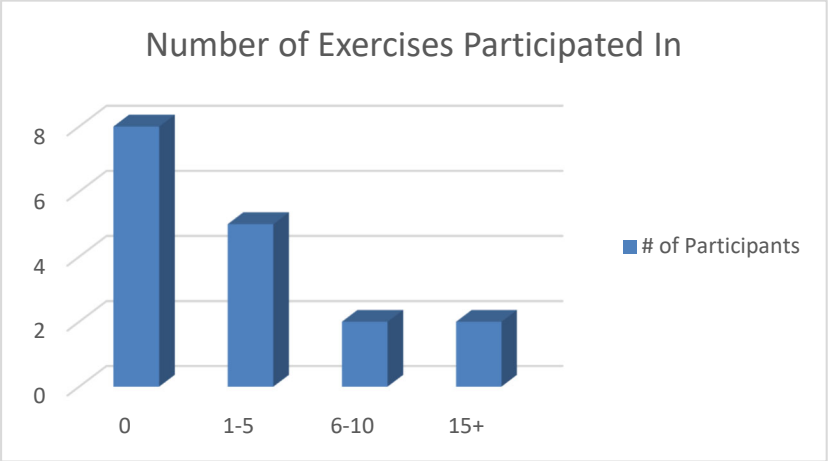
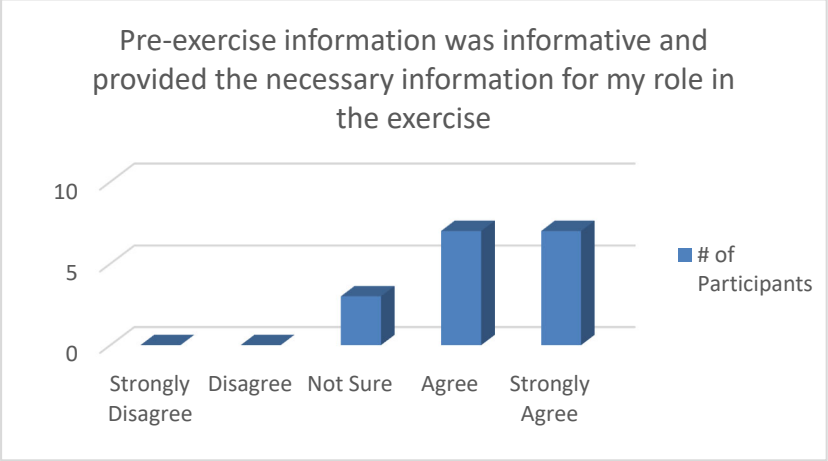
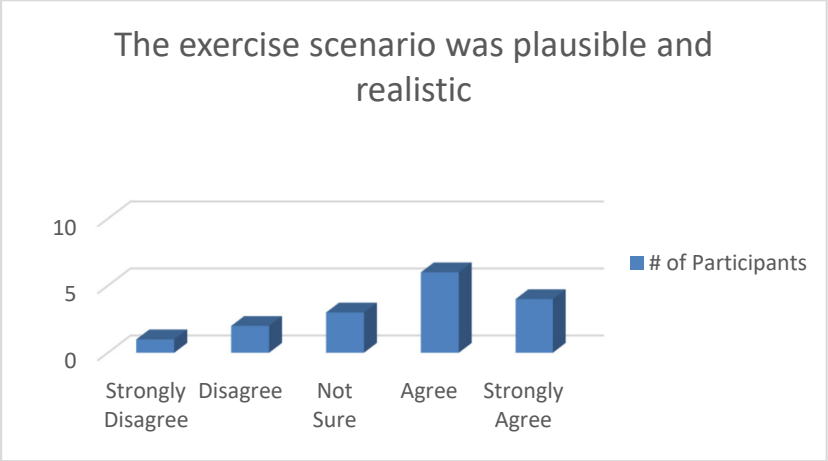
**Denotes Exercise Design Team members.*

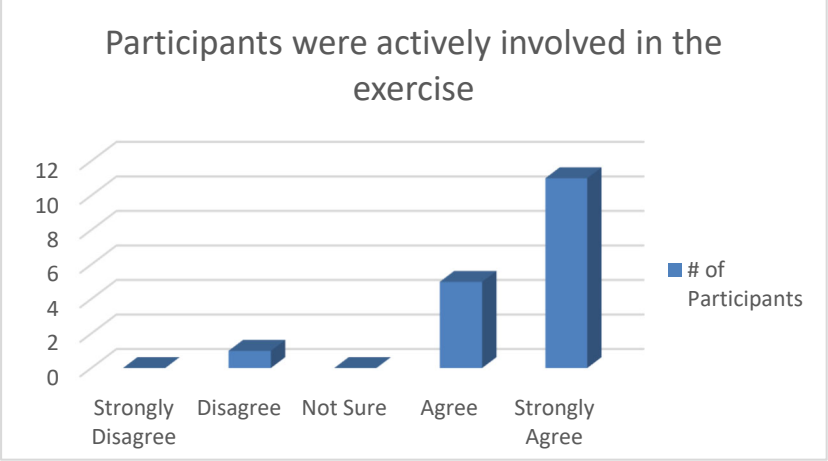
APPENDIX C: PARTICIPANT FEEDBACK








Exercise participants included the right people in terms of level and mix of disciplines
10
5
0
Strongly Disagree
Disagree
Not Sure
Agree
Strongly Agree
# of Participants


Participants were actively involved in the exercise
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8
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2
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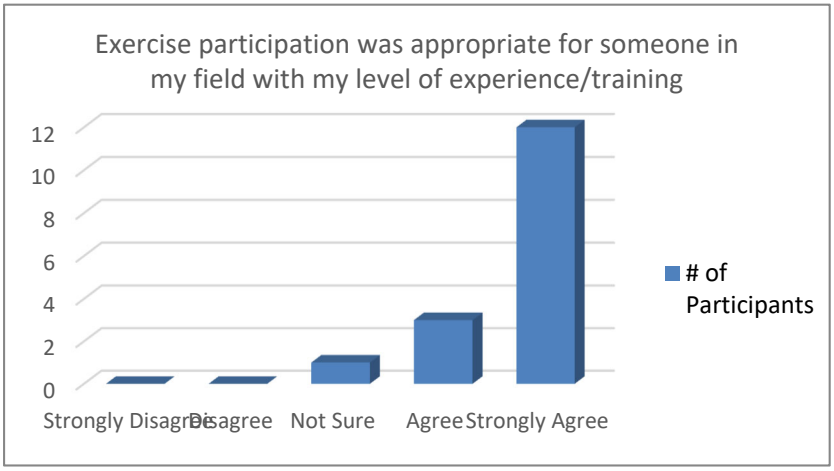
Strongly Disagree
Disagree
Not Sure
Agree
Strongly Agree
# of Participants


Exercise participation was appropriate for someone in my field with my level of experience/training
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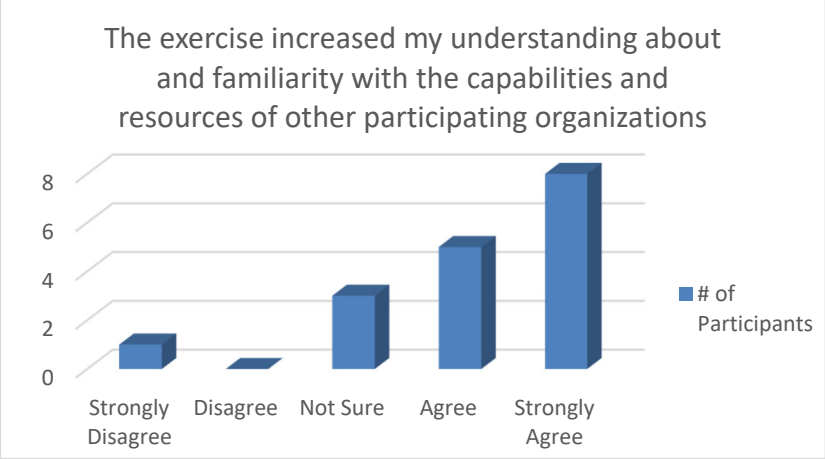
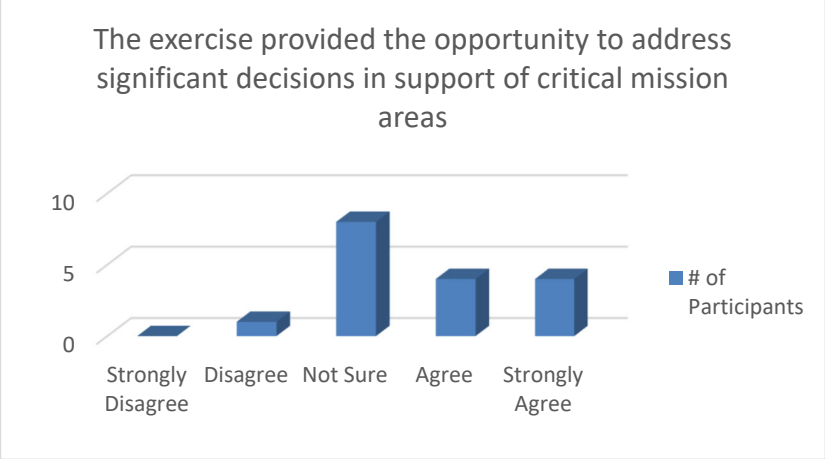
10
8
6
4
2
0
Strongly Disagree
Disagree
Not Sure
Agree
Strongly Agree
# of Participants


The exercise increased my understanding about and familiarity with the capabilities and resources of other participating organizations
8
6
4
2
0
Strongly Disagree
Disagree
Not Sure
Agree
Strongly Agree
# of Participants


The exercise provided the opportunity to address significant decisions in support of critical mission areas
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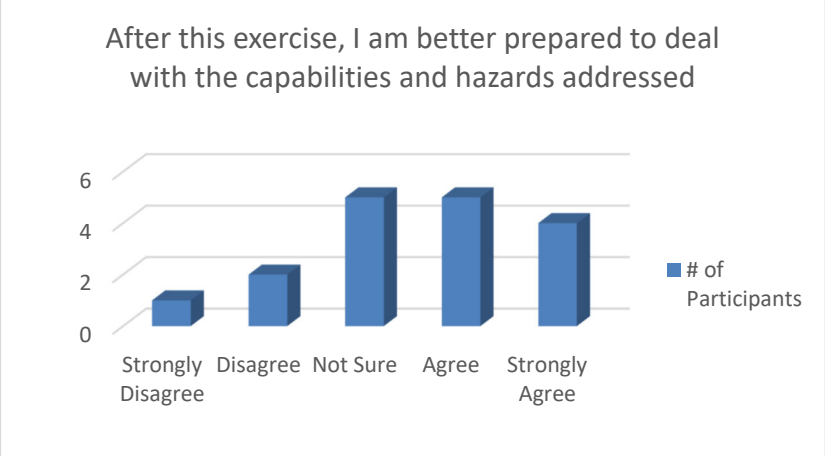
5
0
Strongly Disagree
Disagree
Not Sure
Agree
Strongly Agree
# of Participants


After this exercise, I am better prepared to deal with the capabilities and hazards addressed
6
4
2
0
Strongly Disagree
Disagree
Not Sure
Agree
Strongly Agree
# of Participants

Note: *The following views, thoughts, and opinions expressed in the text below belongs solely to the author, and not necessarily to the organization, committee, IWG, or other exercise participants.*

I observed the following strengths during this exercise:

- Folks seemed very engaged in resolving how to conduct event-response.
- Understanding the need to coordination with state and feds throughout event.
- Agency representatives were honest and forthcoming about their abilities, roles and responsibilities, resources, and about how a given HAB response would operate. I got a much better understanding of how all the agencies contribute to HAB responses, including how interactions across agencies and with state/federal entities occur.
- Good Range of agencies; one state expert in each group to provide the state level actions
- Federal participants with less experience in HAB response gained greater familiarity with the important role\leadership of state agencies.
- Significant number of SMEs participating all knowledgeable about HABs.
- Good representation across agencies for each group.
- The inclusion of regional/local participants.
- People were afforded good opportunity for input. The objectives/questions were concise.
- Connections with other fed organizations
- Good mix of stakeholders
- Good participation from a variety of state and federal parties

I observed the following areas for improvement during this exercise:

- Need for formal plans for event response, interagency communication mechanism, need better definitions of blooms of National interest.
- Some confusion as to if event was regarding Texas ONLY response or each participates response to the event from their respected agencies (which I think was more valuable).
- I appreciated the opportunity to examine one geographic area for which freshwater and marine aspects would apply. I think ensuring that each group has a similar makeup of agency representatives would help in terms of being able to discuss everyone's contributions to a given scenario. Also ensuring that multiple representatives from the geographic area being discussed are participating would help to keep things realistic. I was encouraged that the following areas for enhanced coordination were identified: developing certain plans and procedures or templates for specific types of events, ensuring that we coordinate and enhance communication as needed across jurisdictions (and with respect to our differing approaches), working toward more types of coordinated pre-planning beyond past ad-hoc approaches. In addition to continuing to leverage resources as able, and thinking about other states' approaches for inspiration.
- none- good discussion; the final report/action steps will help to see the effectiveness of the information collected

- Exercise discussion focused more on monitoring and situational awareness rather than response actions necessary to mitigate and to assist impacted communities.
- Report outs were repetitive and too long.
- Most federal participants did not understand that states have primary responsibility. Many parts of NOAA with significant expertise were left out. The steering committee was heavily weighted to freshwater HABs. Many of the agency presentations were about their HAB research and involvement, NOT their HAB response capabilities, maybe because they don't have any at this time. There should have been a presentation on the National HAB Observing System that is being developed.
- I would try to come up with a scenario in which the event to be responded to is not part of a larger event that would make participants think about other issues. It wasn't an issue for me per se because I just pretended a bunch of things were not factors

  But my reason for being there was to provide input with respect to bivalve molluscan shellfish issues. If a Category 4 hurricane hit the State would shut down shellfish harvest in the vicinity for an extended period regardless of HAB issues. I talked to the FDA Shellfish Specialist who covers Texas and he said he thinks it would be at least four weeks.

  Another thing is that there is a strong likelihood that a rapid crash in salinity such as that described would cause extensive oyster mortality. The bottom line is that the HAB issue would likely be moot with respect to bivalve molluscan shellfish harvest.

  As noted, I just pretended none of those things were issues based on discussion just prior to the exercise, but it would be better if a scenario did not include something that would generally be a major disaster. I would pick something where the HAB issue would be the only big thing going on.
- Need for a central fed team to act as a POC for fed HAB response
- Breakout groups could've been more diverse group of agencies (I think we had 3 or 4 from my agency in my group)
- It was difficult to generalize the response to a hypothetical response in Texas to a wider area of the country due to the widely disparate capabilities in other states.

What specific training opportunities helped you (or could have helped you) prepare for this exercise? Please provide specific course names if possible.

- The risk communication presentations were very useful to me during the meeting ahead of the exercise.
- I think for me was not training as much as experience with a similar event at home (NOT in TX) and seeing the response (or lack of response) to the event was critical to understanding how to proceed any future events.
- I thought that the information included in the manual gave enough background to be able to participate in this exercise. Perhaps a little more information about past state and federal agency interactions on these subjects would have been helpful, but that information was easily shared during the discussions.
- More case studies of HAB event response, so that the range of problems and possible federal assistance could be addressed.
- Cannot think of any. My role was narrow and within the National Shellfish Sanitation Program (NSSP) we have a pretty good idea as to what would transpire with respect to Shellfish Growing Areas in a situation like a cyanobacteria bloom. The process is less well described for cyanobacteria than it is for something like Karenia because we do not pre-existing limits for toxins unless the toxin is saxitoxin. But the NSSP has had a lot of focus on the general issue of HABs threatening shellfish growing areas. Also I cover Louisiana and have thought for some time that cyanobacteria is a potential issue for that State's growing areas due to all the freshwater discharge. I have spent a lot of time communicating with researchers who study cyanobacteria.
- Better understanding of the type of impacts from this HAB
- Knowing more about federal involvement and potential support was helpful. Knowing that other states have similar limitations in response capabilities was good to hear. It would have been more helpful to have state representatives from Utah or some other states that have more robust HAB response protocols in place.

Which exercise materials were most helpful? Please identify any additional materials or resources that would be useful.

- Exercise materials were sufficient to execute the tabletop exercise.
- All of the provided materials were useful.
- I think the realization that most agencies (state and Federal) have not addressed blooms as a serious hazard that needs planning and SOP for these events.
- All exercise materials were very useful, especially the detailed information that was provided in the manual and presentation.
- The seminar was helpful for me as I came from the Emergency Management Community.
- Presentations summarizing agency resources potentially available for HAB response.
- Situational Manual
- I think the scenario document was useful. Can't think of additional resources that would help.
- In person exercise would have been better, but was not possible due to COVID
- Pre-brief
- Materials were good, but as noted above, it would have been helpful to receive information from states with more robust protocols.

Please provide any recommendations on how this exercise or future exercises could be improved or enhanced.

- My state has an established biotoxin program so being given introductory information regarding the support available from federal agencies does not add to our program. The exercise would have to be tailored to the different challenges by region but I am not sure how you could address that many scenarios at once. Even then, in my region we already experience the kinds of scenarios a tabletop exercise would role-play so I am not sure how to improve this to be of benefit to state programs, which experience chronic harmful algal bloom events.
- Could have used some time to condense thoughts for report outs since note taker was not the same individual reporting back, but did appreciate having the note taker.
- Maybe provide 2 different scenarios, one for GOM and 1 for Atlantic as exercise in different geographic locations may provide different outcomes to learn from. Also, maybe provide participates with data on WQ, weather conditions, and bloom dynamics (tracking), seafood testing results, etc. in time series to assess how participates would response to the changing conditions (i.e. the blooms moves across state line, toxins present in areas that can pose hazards to people and pets, public information and response, seafood effects, economic impacts, etc..). So, the exercise could provide just enough information for 1 week at a time, and then as the exercise proceeds add new information with changing conditions, until end of event. This way the participates have to response to current situation and then response to the change in conditions on the fly.
- Perhaps plan to have some discussion with a subset of participants to follow up on the recommendations or gaps that were identified in the exercise. Some of the recommended areas for improved response would be good to act on during a follow-up workshop or event, and I feel that DPP (and perhaps the IWG) could assist in facilitating some of these efforts.
- Well done- I was concerned about the virtual nature of the exercise, but I would say it went well and there was good discussion and information exchange.
- Focus exercise on Federal and State/Local coordination frameworks to answer how we, as a nation, will respond together, if HAB is impacting a small region.
- The next time, if there is one, the first two days should be for all regions, and then there should be region specific tabletop exercises, with individuals, both federal and local, from the specific region.
- HABs are mostly state level issues, so coordinating a federal response is difficult is dependent on the specific need of the event

APPENDIX E
Tabletop Exercise Participants

Participating Organizations	
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**Denotes Exercise Design Team members.*

APPENDIX F
Tabletop Exercise Breakout Group Notes

Group 1 Notes

Module 1

1. **Which agency(ies) should be communicating/coordinating to respond to the cyanobacterial bloom in Galveston Bay? Which agencies should respond to the dog death?**
   - Other general thoughts - shellfish effects, state shellfish groups, shellfish closures, cyanotoxins and FDA involvement/expertise, marine/freshwater continuum, dealing with new contaminants in area with shellfish
   - Teri - Very real scenario; algal mat effects on cetaceans is another consideration
   - Mark (NOAA/NCCOS) - Quay also mentioned that HAB event response program through NOAA, we engage when contacted by state/university counterparts (or others we are funding). Ask state counterparts since they are primary responders to jump in.
   - Bryant - Yes, that is us. Hurricane unlikely in Maine to happen but have still looked at cyano/microcystin impacts in estuaries. Would still be responding to something like this. We are responding anyway since treatment plants could be overflowing, harvest areas will be shutdown likely. State authorities (and appropriate agencies) would be first line.
   - Al - Patterned after Bonnie Carey spillway for answer. State agencies (DEQ and Dept of Health - have shellfish responsibilities for DoH) would try to coordinate on any public announcements. No formal protocol, but DoH trying to put something together. Communications with Fish advisory folks too who are helping lead that. Would also be working with NOAA, USGS who would be able to help.
   - Scott - Spillway openings forecasted (like hurricanes) and so can prepare. Work with USACE to do analysis/water quality sampling (toxins, algae) - looking at beach areas, swimming areas in warm periods, boating. Work with LA DEQ and DoH. Also looked in state park during event and can help with announcements in those areas.
   - Sean (USACE) - USACE depends on operational relevance - if reservoir or flood control, then could be under flood operation. If non-flood operation scenario (if storm path missed USACE project) then could have structural release, etc to flush out algal blooms and work with other agencies to make that happen. Generally, our authorities are quite limited, esp. In this area. If there's a federal declaration could be brought in through FEMA assignments though.
   - FEMA mission assignments could potentially happen that are outside typical purview, but no instance yet through Federal declaration to do anything with HAB.
   - Jon (FDA) - Main involvement would be seafood safety. Primary agency for seafood safety. For shellfish, it's unique. Managed under state-Fed program (ISSC). Bryant is state counterpart for this program, for example. NSSP also has rules/requirements for measuring toxins. Cyanotoxins not necessarily occurring, so not as specific rules, but there are rules for emerging threats (this would apply here). Work with TX department state health services (would determine if safe for harvest); also communication with them for advising and if complying with ISSC requirements. If no capacity to test for toxins, then can reach out to us for that. Did similar thing in CT where cyanobloom entered estuary and looked to see

degree of associated toxins. Follow rules of ISSC and if need assistance, then FDA provides that.

State level response:

- Al - Have vet who works for department. Would be state public health veterinarian with Office of Public Health, in department of Health.
- Bryant - Looked at website, would be dept. Health, but not as familiar - concur with Al.

2. Does your agency have a process/plan/procedure in place to respond to a cyanoHAB event in freshwater water bodies? If yes, what does the process/plan/procedure cover (or address)?

State

- Al - No protocol right now - hoping Dept health will put something together and will eventually coordinate with them.
- Bryant - Al's response is reality in that state. For hypothetical response for cyanohab event, there are actions you take pre-hurricane event and actions b/n time of hurricane and bloom detection. Prior to bloom, procedures would be precautionary closures with foreknowledge that conditions could affect shellfish harvest.

Federal

- Teri- Work through SE Regional Office with hurricane in GOM, there would be work with local stranding network and local researchers to get feedback and know what resources are available. Watch and see how water quality is affected and work directly with NOAA HABs partners to get information. Have also reached out to the state (incl. TX HABs office) to see if there are any strandings or animal mortalities.
- Scott - No procedures/protocols in place to go after cyanohab blooms. Respond to collection needs. May also happen with another partner agency.
- NCCOS also has broad suite of response capabilities (see Rick's talk, Kaytee's/Mary Kate's posters). With request from state partner, there can be development of satellite tracking of cyanobacterial blooms with Rick's team. Additional support for sampling, ship time for states/academics who are engaged for sampling capabilities.

3. What agencies provide science-based information related to the cyanoHAB event in a freshwater environment that could be used to help decision-makers? What type of information is provided?

- Sean - Have water quality authority, particularly with reservoir process. Generally limited to measurements of temperature, DO. Other projects have towers that can pull water from, but not in all cases. Gist of information being collected, and not monitoring for cyanobacteria.
- Jon (FDA) - Decision on safety to harvest falls on states. No set cutoffs for cyanotoxins. If state measured them then we could assist on determining what safe consumption levels would be. Would take data and turn over to Office of analytics and outreach, determine potency, avg. consumption of that product - risks to adults v. children. Make decision if product safe or not and influence state decisions about harvest closures.

- Have also thought about blue-green algae included in products and have tested for risk that might be associated with those products. Could potentially apply that to shellfish too.
- Bryant - Gray area since not a set standard and can't necessarily point to exact number for a decision. In one-off event like this, we go conservative or perhaps think about EPA drinking water standards as a guideline. Would also ask FDA as needed. Ultimately think about conservative as a rule.
- Al - regional staff could take DO, pH readings, water quality, etc. Also, some cyanobacterial testing - probe-based. Also try to get that data and inform the public based on those data.
- Ultimately, best available science would be used for something like this (Applies to all feedback on this question).

Module 2

1. **Which agency(ies) should be communicating/coordinating to respond to the cyanobacterial bloom in the Gulf of Mexico?**
    - Al (Louisiana DEQ) - Same for before. Exception is if get into marine mammals/turtles/etc. Wildlife and fisheries might get involved, marine mammal stranding group (LSU). From state agency perspective it stays the same. Our limit for state waters is 3 nautical miles.
    - Marc (NCCOS) - Be involved early on and then continue. Much of the same thing. Continue to provide satellite capabilities, coordinate efforts among various groups, provide event response support/funding. As it moves offshore and expands, idling cruises of opportunity might become more important. Could collectively provide support to add people/ship time to better track the bloom in coastal waters.
    - Teri (NMFS) - Would work with local stranding network folks for turtles/mar mammals. If animals are affected, we would be looking at the numbers of animals that have died and if passing a given threshold then consult with subject matter experts. Would also work with funding/reimbursements and grants partners, organizations who can conduct analyses for NOAA. Keep contracts with experts to keep the information flowing and to be able to detect toxins as able. Also look at food web effects, prey items and potential sources of toxins, test water as able from shore and offshore, examine which animals are in trouble, ask for public input through available hotlines. Provide best management practices to prevent taking of turtles/marine mammals as well.
    - Scott (USGS) - Normally work in nearshore, coordinate with NOAA/other agencies for offshore. Depends how far out, location. Use satellite imagery from NOAA and can provide monitoring, water quality, toxin sampling. Boats and capacity to do that work; sensors for data collection. Work with DEQ and Dept of Health as needed if collecting oyster samples or similar. Some USGS staff work with marine mammals but most of that focus would fall under other agencies. Mainly for water quality sampling, gauge stations, TX has gauge station network too, esp. available offshore locations (can look at salinity, other properties). Saw freshwater effects on dolphins in 2019 too, which is of interest to USGS.
    - Jon (FDA) - Like previous scenario. FDA regional specialist in contact with TX state agency and relay information back to HQ. State is responsible for anything harvested in state miles (in TX that is 9 nautical miles). FDA in collaboration with NOAA is responsible for safety in

federal waters. Chances of cyanobloom persisting that far out is unlikely, but if it did, then would be NOAA/FDA for federal waters. Also interests in aquaculture in some of these Gulf areas and would need to consider aquaculture operations to make sure the shellfish was safe.

- Sean (USACE) - Operational protocols would be the same. Also related to last session and here, we have some things in our water control manuals and authorities to do planned/unplanned/emergency deviations and protocols on how to carry them out - not explicitly for HABs but could be applicable.
- Bryant (Maine Shellfish) - Al covered things from state perspective, manage similar along shore or as it moves out. Even if it goes past state water limits, they will do one last communication with the public as it leaves their jurisdiction/authority to make the public aware.

2. **Does your agency have a process/plan/procedure in place to respond to a cyanoHAB event in marine environment? If yes, what does the process/plan/procedure cover (or address)?**
   - Al (LA DEQ) - Currently no.
   - Bryant (Maine Shellfish) - Nothing in writing for our agency to deal with cyanoHAB event. Would have to affect marine waters for our jurisdiction. Different state agency does freshwater, and they do some baseline monitoring for freshwater HAB events. No protocol for a hurricane-related event like this that would lead to freshwater-marine transfer. Would use many similar procedures to a marine HAB but use different testing methods. Still would solicit FDA help if we could not test ourselves, especially if something more novel or unfamiliar.
   - Jon (FDA) - No specific plans for cyanoHABs but guidance levels are set for marine biotoxins (would fall under emerging). Products can't be adulterated, but for something that's naturally occurring the cyanotoxins would be the same thing and would need to make a decision about what is a safe level. Measure how much, know which toxins and their potencies, do risk analysis with toxicologists, determine against thresholds and then work with state. No specific guidelines though.
   - Marc (NCCOS) - With offshore focus, and emerging/unlikely event for cyanoHAB to persist. There are procedures for rapid response in NCCOS and coordination function that has been useful as we heard from earlier part. Multiple agencies (perhaps more so) engaged in marine event. Example is in Gulf of Maine with offshore bloom *Pseudonitzschia* saw importance of each state's responses. This kind of bloom could trigger NCCOS' coordination role again among entities.
   - Reiterate that during these unusual events, then see lots of Federal involvement, especially if state agency starts asking for help or assist with support if there is a lot of focus for one particular state and resources are limited. Help with Gulf of Maine-wide boat surveys (e.g.)

3. **What agencies provide science-based information related to the cyanoHAB event in a marine environment that could be used to help decision-makers? What type of information is provided?**

- Al - Like before. Agency (LA DEQ) does not do much of that sampling. Could do meter reading, but any other sampling would come from USGS, NOAA.
- Scott (USGS) - Often coordinate with state agencies, but not much in the water investment funds unless we know it's going to be a long-term event. When FEMA or other agency provides emergency funds, then could help from a monitoring perspective. Did this a lot with 2019 Miss. Sound Bloom and had regular calls with NOAA. Also work with state agencies MDMR and ran analyses through Dauphin Island Sea Lab/U South Alabama. Can also reach out to those types of contacts/colleagues.
- Sean (USACE) - Similar as before - not regularly monitoring. If asked to do so, we can and can leverage resources. ERDC can also assist if requested to help with data collection/analysis.
- Bryant (Maine Shellfish) - Same information from same groups for same kinds of decisions. Nothing different from 1st scenario.
- Teri (NMFS) - Information about impacts on sea turtles/marine mammals. Necropsies and tissue collections and sample collections to look at toxins, uptake, metabolism. Those sorts of data from marine mammals.
- Marc (NCCOS) - Primary role either through w/n NCCOS capabilities or with partners is to provide data on the bloom itself (remotely or in water) and movement of the bloom towards resources that might be affected.
- Jon (FDA) - Types of information for seafood safety would be similar. But now that it's in the Gulf would be working with NOAA to see where the bloom is going and make sure that interstate communication is actively happening. Would help with coordinating that communication. Need to know where it's going and what other states would be impacted. NOAA and other agencies would help us with knowing that information.

4. **Does your agency have any assets/capabilities that could be leveraged in this area?**
   - Scott (USGS) - Fleet of boats, personnel. Also buoys/gauge stations are good to think about. There's an already established network, but something to help with following the bloom would be important. Sensor capabilities, toxin analyses (ERDC can help with this). ERDC lab has a lot to offer as far as toxins - also work with LSU. Connections with Al and LA DEQ, also coordinate with them. Can sample certain areas and help leverage on these efforts; also coordinate with different agencies.
   - Sean (USACE) - Like last response and have rigorous labs and some resources to work with HABs. Equipment, professionals who can be brought in to help. If not in-house also strong collaborations with academics and others.
   - Marc (NCCOS) - IOOS has capabilities that could be useful during the 1st scenario, especially GCOOS who maintains a TX network and IFCB that could be helpful. TX has buoy system as well.
   - Al (LA DEQ) - Boats in regional offices could go out to the barrier islands and a little beyond. Regional staff can do this type of work and based on EPA funding for specific funding but HABs not a primary responsibility.
   - Also, a way to have more effective data management and dissemination. Would have regular interagency calls regularly during Bonnie-Cary spillway event.

Group 2 Notes

Module 1

1. **Which agency(ies) should be communicating/coordinating to respond to the cyanobacterial bloom in Galveston Bay? Which agencies should respond to the dog death?**
    - State perspective; state agency Department of environmental protection, state health department would have the contacts to reach out to the local health departments
        - Dog death is animal related and there could be other animals and wildlife that could be affected; fish and wildlife agency, department of agriculture (livestock) may need to be made aware
    - Emergency Management would be involved to a degree, could help coordinate messaging with the hurricane
    - FEMA side: regional response coordination would reach out to ESF10, looking at state requests for federal assistance? If no, situational monitoring and coordination mechanisms. Would not send out resources unless requested to respond.
    - NOAA: If there was a loss of shellfish bed or something else similar, would need a request from the governor and fish and wildlife agency for the state, or if large event affecting fisheries. Can provide remote sensing capabilities.
    - CDC: Expands beyond state capabilities, work with state health department. Dog Death – if concerned with human health we could be brought in to assess the impact of the bloom
    - USACE: engage with Emergency management with imbedded liaison (Galveston / ft worth). More focused on hurricane and less on HAB. Liaison could reach back to the agency to geta access to toolkits and water quality lab (smaller scale tool and can pair with NOAA).
    - Dog death in the bay, we would not be responding. Agencies within Texas will san Jacinto river authority, state health department, kills and spill teams, Texas parks and wildlife.
    - Dog Death = State Level

2. Does your agency have a process/plan/procedure in-place to respond to a cyanoHAB event in freshwater water bodies? If yes, what does the process/plan/procedure cover (or address)?

- State: Yes. Strategy for freshwater HAB. Sampling is done, marine water and freshwater lab have ability to testing for toxins and what and the abundance. Would monitor in the event of the dog death.
- FEMA: ESF, fish and wildlife, or other subject matter experts. If it goes beyond state capacity, may be worth having frequent coordination calls. If it starts to hit the news, the white house will start to ask questions. Establishing coordination mechanisms is key, leader would be chosen
- -NOAA: state managed fishery, looking to state agency for data on the extent of the die off. Local response capability of rapid response and analyze data.

- CDC: if the health department thinks that there is an impact on human health then the CDC will be called. Staff and emergency re, epidemic intelligence officers, health studies section in assessing human health. Ready when the state health department call for assistance. Warning signs would be put up with the health departments

3. What agencies provide science-based information related to the cyanoHAB event in a freshwater environment that could be used to help decision-makers? What type of information is provided?

- State: Science: handheld meters, cell density, volunteers to look at spatial extent and coverage, aircraft remote sensing of chlorophyll, cyano-pigment
- CDC: For the science, look to agency like USGS, NOAA, but we would provide science on human health. Department on laboratory science; can test biological samples for cyanobacterial exposure to provided baseline and connect with environmental

Module 2

1. Which agency(ies) should be communicating/coordinating to respond to the cyanobacterial bloom in the Gulf of Mexico?

- State: Department of health involved right up front, Department of Fish and Wildlife
- NOAA: would not change significantly, would work with adjourning state to track movement of the exposure. Marine mortalities in the area, **office of protected resources.**
- CDC: Coordinate with affected states. Priority to prevent human illness from exposure. Messaging on consuming fish in the area, restricting beach activities, etc. Coordination role for communication.
- USACE: same liaisons with emergency management. Stand by to take direction from other agencies by request. Alert **NOLA district** to be on alert for flood water in the Mississippi river and valley. Coordinate with other agencies to handle increase area.
- Getting navigation back open is a major component. **US Coast Guard**
- OSHA component is an undiscussed component, potential volatilization of the toxins

2. Does your agency have a process/plan/procedure in-place to respond to a cyanoHAB event in a marine environment? If yes, what does the process/plan/procedure cover (or address)?

- State: Into the gulf is covering a much broader area of shellfish waters, microcystins toxin, there is not set level for shellfish, beds would be closed due to the hurricanes anyways. Obligated to monitor even though there is not threshold. Monitoring would expand in coverage; Expand into marine water side.
- biotoxin management plan, know how to monitor and would incorporate satellite remote sensing and air based remote sensing. Rely on FDA and other state agencies and shellfish specialists. Tissue analysis to look for microcystins
- Do not need to wait for FEMA or another agency. NOAA can work with state level to determine emergency. CDC works with state health department. USACE. USCG has port

authorities to implement measures under their jurisdiction and will be primary authority on navigation and they have a marine response mission.
- CDC: response would not change much; scope of potential exposure is widened as it could reach other gulf coast regions.
- FEMA: if economic impact to business expands as a result of the HAB event, covered as part of public assistance possibly as it is a result of the hurricane. Shipping channels and navigation after the hurricane, shipping through these areas and carrying the HAB to other areas (bilge waters). Prevent being able to salvage the ships and debris if there is a 'no shipping' order. Unsure of the solution
- How would it work if the HAB event affected area that is outside of the designated hurricane disaster area since the HAB is a direct result of the hurricane?
- Response based on extent; hurricanes cause infrastructure and vessel damage that ties into assessing fishery damage and could affect multiple fisheries. Can declare fishery disaster w/o governor, can conduct interviews and assessments to determine extent.

3**. What agencies provide science-based information related to the cyanoHAB event in a marine environment that could be used to help decision-makers? What type of information is provided?**
- Like freshwater event
- NOAA; surveys and imagery
- CDC: For the science, look to agency like USGS, NOAA, but we would provide science on human health. Department on laboratory science; can test biological samples for cyanobacterial exposure to provided baseline and connect with environmental

Group 3 Notes

Module 1

1. **Which agency(ies) should be communicating/coordinating to respond to the cyanobacterial bloom in Galveston Bay? Which agencies should respond to the dog death?**
   - HAB response has been a state led activity- feds play a supporting role
     - TexHAB has a document for HAB related response
     - Coordinating across multiple agencies working together to determine who is best suited to respond
     - State may have HAB taskforce- good linkage between states and feds
     - States requesting Federal support depends on magnitude of the event- i.e., multiple dog deaths (looking to CDC and EPA), FDA for shellfish
     - Jurisdictional size and scope matters
   - Having individual contacts and prior relationships

2. **Does your agency have a process/plan/procedure in-place to respond to cyanoHAB event in a freshwater water bodies? If yes, what does the process/plan/procedure cover (or address)?**
   - USGS science centers have established relationships for freshwater
     - Science centers in every state
   - Some States has plan- notification and networking- triggering agency response
     - Slow process to get approval for legislation
   - EPA may be able to mobilize resources
   - CDC- reach out to state public health lab of resources
     - OHAB for reporting
   - NOAA- informal procedure- whoever gets the call can provide contacts
   - FL- State coordination calls across agencies to discuss results
     - Regular communication
   - VA- coordination calls- dog deaths- reaching out to other groups
   - Having infrastructure in place so that states can utilize federal assets- such as adding sensors to gauges (i.e., MOUs)

3. **What agencies provide science-based information related to the cyanoHAB event in a freshwater environment that could be used to help decision-makers? What type of information is provided?**
   - States would be utilizing tools such as USGS gauges
   - NOAA satellite images to provide information and ART for toxin support
     - Funding
   - CDC OHAB
   - EPA webpage
   - CyAN

Module 2

1. **Which agency(ies) should be communicating/coordinating to respond to the cyanobacterial bloom in the Gulf of Mexico?**
   - Same state agencies
   - As soon as there are marine mammal and sea turtle deaths- Sea Turtle stranding and salvage network and Marine Mammal stranding network
     - Network is permitted by the feds
     - Depends on marine mammal (NOAA vs FWS)
     - Networks would be notified by the public or state/local entity
     - UME- NOAA communicating/coordinating on impacts
       - On site coordinator (typically not fed) and communicates with states
       - Messaging comes from central place
   - Multi state effort/ long standing bloom? Provide notifications and updates to help other state entities address impacts

    - Long sustained blooms may bring in issues with aquaculture due to sustained freshwater
- Likelihood of cyanotoxins in aerosols from wave activity- would still be state and local. Guidance for local entities- technical guidance
    - How to message human impacts? Turn to CDC for sign templates
    - Lots of freshwater could stimulate other HABs
- Academic partners for testing related to the bloom or consequences. Make sure academics have tools to communicate with state and feds.

2. **Does your agency have a process/plan/procedure in-place to respond to a cyanoHAB event in a marine environment? If yes, what does the process/plan/procedure cover (or address)?**
    - States evolve based on previous events- incident command system
    - Leads do the work but make sure messaging is centralized

3. **What agencies provide science-based information related to the cyanoHAB event in a marine environment that could be used to help decision-makers? What type of information is provided?**
    - States overwhelmed by sampling need?
        - Not a designated agency in TX, who would make that request for support?
        - Different states have approached that problem in different ways- NOAA has provided funding to do the sampling (NOAA HAB event response program)
    - Rapid testing capabilities would be needed for UME
        - Can take a while for the results to come back
            - Samples sent to labs that don't use rapid methods
    - NOAA
        - ART
        - HAB event response
        - Satellite
    - CDC for health advisory guidance
        - Analysis of clinical samples
    - USGS national wildlife health lab could take birds and work with FWS on sea otters during mass mortalities
    - NASA satellite
    - FDA- shellfish

Group 4 Notes

Module 1

1. **Which agency(ies) should be communicating/coordinating to respond to the cyanobacterial bloom in Galveston Bay? Which agencies should respond to the dog death?**

- If it is freshwater, EPA would be one of the agencies responding to the HAB. It is an informal process where we receive a call from the affected state, in this case TX. It could then go to one of the EPA regional coordinator. Then EPA provides technical assistance. Provide health advisories or states will use their own advisors. Also, how to communicate with the public on health effects and animal effects. Look at and see if there is an intake for drinking water, but there is none in this case.
- USGS- Overall, USGS currently has no congressional mandate to deal with HAB response. We are a research and monitoring agency. We don't have rapid response. We do have potential infrastructure for sampling across the country since we have Science Centers in every state. The dog deaths are outside of our purview and refer it to CDC or another agency. There is a procedure in place for sampling, same as the research studies. The USGS National Wildlife Health Center does respond to a select number of bird mortality events and some of those are related to HAB toxins.
- CDC- Good thing is the event is located in a single location. CDC is public health agency so it would be involved. CDC would have to work with the local departments. Depending on the magnitude of the event, local departments would have to reach out to the CDC. Dog deaths would be a single indicator, we don't know the extent of the HAB. We would ask for the situation to be monitored. Look for unusual spikes in cases of certain things like asthma or other indicators. We do have environmental sampling capabilities.
- NOAA- More of a gray area as EPA and NOAA is involved. Working in collaboration with state and local authorities. Made aware of the event. Coordinate with state and localities. Not much to do with dog deaths. Emergency response funding can be provided.
- Shellfish Authority- Can watch both freshwater and marine reports on HABs. Our response is more on the ground, getting in boats and taking samples, looking at shellfish.
- FDA- Our focus on this exercise is the shellfish. Our role is to provide technical assistance to the state during this kind of incident and evaluate them. Probably reach out to agencies that have expertise in identifying the species of HABs. We have laboratories. Marine events is looking at NOAA information. Offer lab support for microcystin.

2. **Does your agency have a process/plan/procedure in-place to respond to a cyanoHAB event in a freshwater water bodies? If yes, what does the process/plan/procedure cover (or address)?**
   - EPA has health advisories for several cyanotoxins for recreation and drinking water.
   - CDC- We do have toolkits in place related to HABs. Some resources are there for collecting scientific information.
   - NOAA- Could provide emergency response funding.
   - Shellfish authority- Don't have a formal process but have contingency plans.
   - FDA- The national shellfish sanitation program has procedures. They are vague for emerging toxins. Also are procedures for interaction between state and FDA. Has specific formal requirements for saxitoxins, but has less stringent requirements for cyanotoxins currently.
   - USGS has some sampling plans for water measurements of toxins and cyanobacteria.

3. **What agencies provide science-based information related to the cyanoHAB event in a freshwater environment that could be used to help decision-makers? What type of information is provided?**
    - NOAA- Additional support capacities through analytical response teams. Toxin sampling and sample analysis to identify the presence of compounds or toxins. Forecasting capabilities utilize satellite remote sensing. Wait for blooms to occur and try and assess where it is and its extent.
    - EPA- Also provide analytical assistance with sampling, some coordination with USGS and other agencies.
    - USGS - Our biggest role aside from measuring flow/water sampling and things like that that we are already doing, would be getting samples to do research on from a current event to inform response of a future event.

Module 2

1. **Which agency(ies) should be communicating/coordinating to respond to the cyanobacterial bloom in the Gulf of Mexico?**
    - EPA- Not as involved in marine events as NOAA. Do have Gulf of Mexico office. Collaborate with communities around the Gulf of Mexico. Lead for the hypoxia taskforce. A group of federal and state agencies. Help reduce the amount of nutrients in Mississippi River and the Gulf of Mexico. Coordination with the state agency, but give the lead to NOAA since it is marine waters.
    - NOAA- Similar situation to the freshwater event. Forecasting, coordination. Since this is marine it is more clearly for NOAA. Annual monitoring of the Gulf hypoxic zone. Provide support for retroactive monitoring to find the extent of hypoxia from the event. Dolphins were affected. Also reach out and work with sea turtle and other megafauna organizations.
    - CDC- Multistate event now. FEMA would most likely be heavily involved. Monitoring would be the same looking at mortality. If time frame is extended may have to do long term studies in the area to see the effects of the event.
    - State Shellfish Control Authority- Monitoring the water and collecting shellfish tissue. FL fish and wildlife would be leading more than department of environmental protection. Take lead in marine side. Local government agencies would be cooperating as well; different county governments working on things like beach cleanup. State agencies do work similarly to the federal agencies but more specific to their state.
    - USGS- Similar to the answers from module 1. Some caveats. Analytical methods to measure cyanotoxins, in 0 salinity to up to 55 ppt. USGS sits on hypoxia taskforce. Trying to help understand how big the hypoxia may be.
    - FDA- Coordinating with the state and offering consultation. If there was some hazard to shellfish in federal waters, everything would be responsibility of FDA.

2. **Does your agency have a process/plan/procedure in-place to respond to a cyanoHAB event in a marine environment? If yes, what does the process/plan/procedure cover (or address)?**

- EPA- Hypoxia taskforce strategic plan. Reduce the amount of nutrients reaching the Gulf of Mexico.
- NOAA- If dolphins were affected, develop an investigative team to investigate the mortalities. Also reach out and work with sea turtle and other megafauna organizations. There have been similar events in the past.
- CDC- Same as module 1.
- FDA- Do have processes and plans. NSSP. Specific requirements for how to sample shellfish.

3. **What agencies provide science-based information related to the cyanoHAB event in a marine environment that could be used to help decision-makers? What type of information is provided?**
    - EPA- Risk information. Cyanotoxin and risk management guidance.
    - CDC- Same as module 1
    - FDA-Provide information on risk evaluation, and some laboratory work on specific toxins.

Group 5 Notes

Module 1

1. **Which agency(ies) should be communicating/coordinating to respond to the cyanobacterial bloom in Galveston Bay? Which agencies should respond to the dog death?**

    - State of Texas – USGS is non regulatory, they do not do a lot of the response, they provide support and assets largely: including sampling.
    - Texas Commission on Environmental Quality (TCEQ) – State level EPA (regulatory). They would likely help coordinate the effort, but may not do the actual response.
    - Different states have the same response, but it is very state-specific. Many equivalent agencies exist in different states, but names differ. EX: Maryland DEQ, etc. There are analogous agencies in every state.
    - FDA: We are not delineated by fresh or salt water, we would respond to any effect on a food commodity.
    - EPA: Regional Office (Region 6) would lead coordination effort, have existing relationships with state agencies. Local agencies reach out to us if they need help, requiring initiative on their part. They may request monitoring resources, with USGS colleagues, etc. Assessments of Human health risks would be thought of, including beach closures and any action necessary to protect human health. Drinking water perspectives: we are in touch with public water systems impacted, to make sure they have systems in place to treat HABs. In Texas there is a chronic issue of cyanotoxins in source waters. We would have close communication with these resources to make sure they have all assets needed to treat water adequately.
    - Army CORPS: Not too much of a role in this scenario, coordinating with district folks. Reservoir projects would be tied up with their primary mission: flood control. What could we do to change our reservoir projects to control the HAB? Response would be much different for a dry-water HAB.
    - NOAA: NOAA can offer a few different roles in assisting the state: funding under the HAB response program. Quick turnaround rapid funding program, for quick response and sample collection. We help with coordination capacity, with scientists in different states,

allowing resources for sampling. Very closely in touch with other agencies that may provide support. We also have remote capabilities for satellite overflights, etc.
- HAB reference and monitoring group that can conduct sampling analysis and toxin detection. Reach out to scientists directly in the area, and providing funding.
- Shellfish Control Authority: Get in touch with Mississippi department of environmental quality. Authority that would deal with closures related to consumption.
- Which agencies should respond to the dog death?
- Texas Department of State Health Services - Help coordinate, but likely defer to the local health authority (Huston Health Department). Toxicology, autopsy, etc.
- TPWD – Kills and spills team, Alex oversees this program. Can assess fish kills. Has a sea turtle group to help with strandings (Under NOAA, but close coordination).
- Some established networks look at dead sea turtles and dolphins, not related to dog deaths.
- Department of Health would likely spearhead this.

2. Does your agency have a process/plan/procedure in-place to respond to a cyanoHAB event in a freshwater water bodies? If yes, what does the process/plan/procedure cover (or address)?

- NOAA has the capability to implement satellite overflights within a day, projects are currently conducted in Texas, so products can be delivered rapidly. Event response capabilities, and capabilities mentioned above.
- Department of Marine Resources has a marine biotoxin contingency plan, meant for oysters initially, but expanded to shrimp, crab, etc. This document would be what we reference for a significant bloom. History in the Mississippi sound of toxins in fisheries. Work with Department of Environmental quality, which would deal with beach closures, and working in the same labs to identify cell counts, and toxin analysis, to determine if recreation waters should be closed.
- Not much in writing, or a plan, had to adapt to the last massive event 2 years ago. Since then Louisiana has become the frontrunner, coordinating with different agencies, information flowing into the department of health epidemiological units and other units. We first need to see evidence of algal blooms. We recently received a grant to test lake Pontchartrain, due to its high recreational uses, and potential for HAB events. We have begun testing waters to establish a baseline in the area. We will accumulate all the data collected, to come up with a new plan. The biggest issue was a lack of data, but we are moving towards a concrete plan.
- USGS does not have their own plan in place, coordinating with responders and assessment. Member of Toxic Substances coordinating committee, who has a response plan in its draft stage (3rd iteration), however nothing has been completed yet. Maybe next year, this will be in place, and hopefully incorporate outcomes from this workshop.
- NOAA has no plans specifically in place, as far as a response plan, more of a coordinating capability. Mainly functioning in marine systems and estuaries, except when coordinating directly with EPA. This is highly a case-by-case basis for response, based on individual needs and species impacted.
- EPA: Since this is a hurricane scenario, we have a hurricane response division that would likely respond to this area, with capabilities to help with the bloom event. Possibility for direct support if tasked to do so.

3. **What agencies provide science-based information related to the cyanoHAB event in a freshwater environment that could be used to help decision-makers? What type of information is provided?**
    - Louisiana: Relying heavily on satellite imagery from NOAA and EPA, transitioning to more sampling, however the data resources are extremely helpful from overflights.
    - Gulf of Mexico Alliance has a document in place with HAB response procedures in place for response across the GOM. Procedures and methods in place in this document for both state and federal response.
    - NCOS updates its webpage based upon needs for specific events. Not in a general form. Updates webpage with banner to allow easy access (on a case-by-case basis).
    - Texas – Mainly falls to local authorities to do independent testing, then coordinate at a higher level.

Module 2

1. **Which agency(ies) should be communicating/coordinating to respond to the cyanobacterial bloom in the Gulf of Mexico?**
    - FDA: not delineated by fresh vs. marine. But concerned with food with HAB toxins, especially for interstate commerce. For the GOM, if we move the event offshore enough to federal waters, NOAA and FDA would work as co-leads working with other agencies for response.
    - Louisiana: More concerned with something along the lines of violating out oyster ISSC rules and regulations withing NSSP, due to hazardous events, etc. The bloom itself- would likely looping in more of EPA, FDA, NOAA. In the first scenario locals may have gotten the data, and brought discussions to the federal level. In this scenario we are having federal entities notified.
    - Mississippi Department of Marine resources: Need for communicating with adjacent state agencies. In previous events, Alabama notified Mississippi for the possibility of an event before they entered Mississippi waters.
    - NOAA: Would work in a similar capacity as the previous scenario, but would focus on protected species and any unusual mortality events.
    - EPA: Gulf of Mexico program office, not necessarily strictly response, but can provide help with coordination, monitoring, etc. Several task forces like the Hypoxia task Force (multi-state) would be included in the response, and helping with coordination.
    - Army CORPS: Maybe even less of a role than the last scenario, due to the coastal environment. We have dealt with other HABs that occurred as result of some of our project operations, but in this event, not much. Not much infrastructure is in place in this area.
    - USGS: Not mandated to respond, but would help on a research basis, and can provide assets if needed. Do engage in some offshore work, but again, not mandated.

2. **Does your agency have a process/plan/procedure in-place to respond to a cyanoHAB event in a marine environment? If yes, what does the process/plan/procedure cover (or address)?**
    - NSPS guide for shellfish that provides general requirements and guidance from the FDA.
    - Louisiana: Does not have an official plan in place, currently in the works. Figuring out contacts to call, species-specific responses, etc. No plan in place even to contact neighboring

states. Lack of a media lead, and one agency to take initiative. Working towards a centralized response document/guidance.
- Marine Biotoxin Contingency Plan: Since 2019, we have expanded this plan to include cyanobacteria in the area. Has had coordination with other state agencies in the past.
- NOAA played a significant role in HAB monitoring for previous events using satellite assets. In the case there was an unusual mortality events (marine mammal focused, US fish and Wildlife and NOAA run), there is an established sequence of events and working group that would determine the cause of the event. If related to cyanotoxins, there are plans in place and rapid funding available.
- Request from DEQ: Look into various lakes that feed into lake Pontchartrain, taking into account for future plans. Initial sampling protocol is mostly to sample lake Pontchartrain. Relying on ground-truthing and remote sensing. LDEP closed off lake Pontchartrain due to recreational activities, and popularity of the lake. Not necessarily ready to close other lakes in response, need baseline data.
- EPA: After the event, the GOM program office has a resiliency focus, and how to focus on recovery of resources after an event.

3. **What agencies provide science-based information related to the cyanoHAB event in a marine environment that could be used to help decision-makers? What type of information is provided?**
    - NOAA/EPA use of satellite imagery. Someone such as coast guard may be an asset further out offshore, ability to mobilize boats and use vessels of opportunity for additional data and images. Loop in wildlife and fisheries, as they have the vessel capability and knowledge of offshore areas (similar capabilities as USCG).
    - FDA: Can offer science based information in the form of technical assistance, such as looking at levels of cyanotoxins in shellfish consumption. Can provide analytical support for cyanotoxins and shellfish. Interagency efforts include EPA, CDC, NOAA, looking at toxins in algae or shellfish in federal waters.
    - NOAA can serve in a similar capability, with their aquaculture sighting group, through NOAA's participation in the aforementioned working group. Providing science-based information, supporting collection of information where there are gaps identified.
    - Internationally: Intergovernmental Oceanographic Commission (IOC) - HAEDAT database are maintained through intergovernmental panel for HABs. There data would be input into this system, opposed to receiving a product. Can be used for historical data analysis.