NCCOS FY19 HARMFUL ALGAL BLOOM PROGRAM AWARDS

Florida Harmful Algal Bloom Socioeconomic Assessment

Institutions: U.S. Integrated Ocean Observing System (IOOS), Gulf of Mexico Coastal Ocean Observing System (GCOOS)

Project Period: September 2019 – August 2021

Location: Florida and Gulf of Mexico

FY19 Funding: $600,000

Project Summary: This collaborative effort with the U.S. Integrated Ocean Observing System (IOOS)/Gulf of Mexico Coastal Ocean Observing System (GCOOS) will fund studies to investigate the sociological and economic impacts of the 2017-2019 *Karenia brevis* harmful algal bloom (HAB) in Florida. One to two projects totaling $600,000 will be competitively funded for a two-year socioeconomic study. The aim is to quantify the socioeconomic impacts of this extensive HAB event and develop a framework to inform future socioeconomic assessments of HAB events.

NCCOS awarded GCOOS $600,000 to run the award competition and select grantees. Two projects were selected in March 2020:

A) From Bloom to Bust: Estimating Economic Losses and Impacts of Florida Red Tide (*Karenia brevis*)
B) Assessment of the short- and long-term socioeconomic impacts of Florida's 2017-2019 Red Tide event

From Bloom to Bust: Estimating Economic Losses and Impacts of Florida Red Tide (*Karenia brevis*)

Institutions: University of Central Florida and University of South Florida

Location: Florida

FY20 Funding: $137,122

Total Anticipated Funding: $277,122

Project Summary: The true costs of harmful algal blooms (HABs) and the mechanics that determine their devastating socio-economic impacts are largely unknown. Florida's 2017-2019 *Karenia brevis* bloom, also known as "red tide", is a historical case study of the ever-growing threats to coastal welfare, but could also be an early indicator of possible adaptation strategies. This two-year project will examine the economic impacts of *K. brevis* events across 80 different economic sectors, based on varied bloom occurrence and intensity. This approach is designed to identify specific interactions and experiences that drive human behavior which intensifies the economic impacts of natural hazards such as HABs. The analysis will focus on a diverse group of Florida state economic sectors, including Tourism (e.g., hotels, restaurants, boat rentals, fishing guides), and commercial fisheries, in addition to those economic sectors that have been impacted by HABs, but have received less attention in socio-economic studies (e.g., health care and veterinary services, retail, construction). Understanding the true social and financial costs of HABs is key to developing effective response and adaptation strategies that meet the needs of impacted communities in Florida and around the country.

Assessment of the short- and long-term socioeconomic impacts of Florida's 2017-2019 Red Tide event

Institutions: University of Florida and Texas A&M University Corpus Christi

Location: Florida

FY20 Funding: $160,616

Total Anticipated Funding: $279,796

Project Summary: Harmful algal blooms, or HABs, occur when colonies of algae grow out of control while producing toxic or harmful effects on people, fish, shellfish, marine mammals, and birds. In Florida, the most common HABs are known as "red tide", caused by the marine algae species *Karenia brevis*. The most recent *K. brevis* bloom lasted almost two years, from October 2017 - 2019, marking the first red tide event ever observed on the Atlantic Coast of Florida. The bloom devastated businesses state-wide, and had far reaching sociological effects among Florida's coastal communities. This two-year project will develop a transferable framework, in the form of practice guides, to help inform national-scale efforts to quantify the socioeconomic impacts and measure community resilience to HABs. This effort will supplement ongoing discussions related to mitigation and prevention of HABs and their associated impacts amongst academics, federal, state, and local policymakers, industry stakeholders, recreational users, and the general public.

ECOHAB: Oceanographic and Cellular Controls on Domoic Acid Production in the Central and Southern California Current System

Institutions: University of California San Diego/Scripps Institution of Oceanography, J. Craig Venter Institute, Monterey Bay Aquarium Research Institute, Southern California Coastal Water Research Project

Project Period: September 2019 – August 2023

Location: California

FY19 Funding: $961,265

Total Anticipated Funding: $4,943,928

Project Summary: Domoic acid (DA) is a potent neurotoxin produced by some diatoms in the genus *Pseudo-nitzschia* (PN). DA can accumulate in shellfish and fish and cause illness or death in humans, marine mammals, and birds. In 2015 a severe bloom along the US West coast devastated the crab fishery and resulted in prolonged harvesting closures of other fish and shellfish. This project provides a comprehensive regional research program to quantify the oceanographic and cellular factors that regulate and promote DA biosynthesis in the California Current System (CCS). Recent breakthroughs in automated sampling, biogeochemical characteristics of toxic and non-toxic blooms, and the discovery of the DA biosynthetic pathway, support the investigation of how oceanographic conditions and cellular physiology regulate toxin production. The project aims to increase the understanding of the factors that control the distribution and activity of the DA biosynthesis pathway and DA concentrations in the southern and central CCS.

ECOHAB: Multidisciplinary Approach to a Cross-Regional Problem: *Dinophysis* and DSP Toxicity

Institutions: College of William and Mary/Virginia Institute of Marine Science, Jamestown S'Klallam Tribe, NOAA Northwest Fisheries Science Center, Stony Brook University, Texas A&M University, U.S. Food and Drug Administration, Woods Hole Oceanographic Institution

Project Period: September 2019 – August 2023

Location: National

FY19 Funding: $999,819

Total Anticipated Funding: $4,996,236

Project Summary: Diarrhetic shellfish poisoning (DSP) is emerging as a significant and expanding seafood safety threat in coastal regions across the country. Despite the immediate threat to human and ecosystem health, little is known about the environmental and biological drivers *of Dinophysis* growth and toxin production, species or strain variation, or the relative toxicity of the novel *Dinophysis* toxin dihydro-DTX1. This project will develop a nationwide network of Imaging FlowCytobots optimized for monitoring *Dinophysis* blooms to investigate environmental and biological drivers of blooms and toxicity in and across regions. These monitoring data will allow the quantification of *Dinophysis* growth rates and toxin production, and the evaluation of the impact of climate change on the risk of DSP across the U.S. The results of this project will be communicated with state, tribal, and industry groups to address regional management needs.

ECOHAB: Life and Death of *Karenia brevis* Blooms in the Eastern Gulf of Mexico

Institutions: Mote Marine Laboratory, Bigelow Laboratory for Ocean Sciences, Florida Fish and Wildlife Conservation Commission, New York University-Abu Dhabi, University of Maryland, University of South Florida

Project Period: September 2019 – August 2023

Location: Florida and Gulf of Mexico

FY19 Funding: $1,901,115

Total Anticipated Funding: $4,999,995

Project Summary: An extensive bloom of the brevetoxin-producing *Karenia brevis*, the Florida red tide, occurred from 2017 to 2019 in Florida. Brevetoxins accumulate in shellfish, requiring shellfish harvesting closures, and kill fish, marine mammals, birds, and turtles. The toxins can be aerosolized by wave action, causing respiratory problems among beach goers. The economic and ecosystem impacts were quite severe during this event. This regional project builds on prior NCCOS-funded *K. brevis* research and applies new field, laboratory, and modeling approaches to better understand interannual variation in the magnitude and duration of Florida red tides. It focuses on the physical, chemical, and biological factors associated with *K. brevis* bloom termination. Project data will include historical bloom analysis, measurements of the predominant physical forcing mechanisms acting on bloom expansion and termination, and laboratory and field measurements of nutrient availability, mixotrophy and associated bacterial and viral communities in later bloom stages. New machine learning and mechanistic models of *K. brevis* will be used for scenario testing and forecasting of the impacts of large scale extreme weather events.

MERHAB: HAB Observing Network - New England (HABON-NE): An Adaptive Observing Network for Real-Time, In Situ HAB Monitoring and Data Sharing Across New England

Institutions: Woods Hole Oceanographic Institution, Florida Fish and Wildlife Commission, Northeastern Regional Association of Coastal Ocean Observing Systems, NOAA NCCOS

Project Period: September 2019 – August 2024

Location: New England

FY19 Funding: $595,900

Total Anticipated Funding: $2,977,045

Project Summary: New England coastal waters have long been impacted by *Alexandrium*, a species that causes paralytic shellfish poisoning (PSP). Other species have recently emerged in the Gulf of Maine, including *Pseudo-nitzschia* and *Dinophysis,* capable of producing toxins that can cause amnesic shellfish poisoning (ASP) and diarrhetic shellfish poisoning (DSP) syndromes, respectively. Other fin- and shellfish killing species have also recently appeared in the Gulf of Maine. Emergence of all these species has resulted in nearly year round HAB threats that may negatively impact aquaculture, fishing, and tourism in this region. This project creates the HAB Observing Network - New England (HABON-NE), aligning academic, industry, state, and federal scientists to deploy a fleet of advanced sensors, including the Environmental Sample Processor and Imaging FlowCytobot, and mobile sensor platforms, including PhytO-ARM and SeaTrac ASV. This extensive network will enable year-round monitoring to meet changing seasonal threats and respond to unexpected ones. HAB cell and toxin observations, model outputs, contextual data, and management actions will be shared with resource managers and stakeholders as they are created through the WHOI HAB Hub (WHHub). This existing, open source platform facilitates regional-scale integration and sharing of HAB information.The project will also implement a toxicity model that translates high frequency, *in situ* estimates of cell concentrations into estimates of PSP toxin loads in shellfish derived from ESP data. This modeling effort will evaluate the feasibility providing toxicity estimates as part of the NOAA NCCOS Gulf of Maine *Alexandrium* forecast model output. This project will significantly advance HAB monitoring in the region and beyond.

MERHAB: Strengthening Early Warning and Forecasts of Domoic Acid Events in the Pacific Northwest: Using the Environmental Sample Processor to Close the Data Gap

Institutions: University of Washington/Applied Physics Laboratory

Project Period: September 2019 – August 2024

Location: Pacific Northwest

FY19 Funding: $299,884

Total Anticipated Funding: $1,499,202

Project Summary: In the Pacific Northwest (PNW), blooms of *Pseudo-nitzschia* that produce domoic acid (DA) are a significant human health threat and extremely costly to coastal communities. They have caused prolonged closures of the commercial, subsistence, and recreational razor clam fisheries and at times devastated the commercial Dungeness crab fishery, resulting in millions of dollars in lost expenditures and federal fisheries disaster declarations. This project improves early warnings and forecasts of DA events in this region. Existing Second Generation Environmental Sample Processors (2G ESP) off the coast of Washington will be modified with mission enhancing and cost-saving upgrades to enable more frequent, regular, and reliable offshore monitoring. The project will improve ESP communications, the number and length of deployments, and sampling capacity to provide real-time offshore DA levels throughout the HAB season. This enhanced ESP data will be incorporated into existing forecasting and management tools, providing early warnings of blooms, and improving the accuracy of PNW HAB Bulletin forecasts. The project builds on prior NCCOS/CRP and IOOS investments in the PNW to advance monitoring and forecasting of DA events.

MERHAB: Microcystins in Bivalves: Optimizing of Monitoring for and Minimizing Risk From an Emerging Human Health Threat

Institutions: Stony Brook University, University of California Santa Cruz

Project Period: September 2019 – August 2021

Location: Nationwide (potential application to any locations with shellfish and CyanoHABs)

FY19 Funding: $597,206

Total Anticipated Funding: $905,300

Project Summary: This project addresses an emerging concern across the U.S.-- the transfer of freshwater algal toxins into the marine environment where they can infiltrate the food web and present a health risk to both humans and wildlife. Multiple bivalve species (wild, caged\sentinel, and farmed) will be sampled from a number of East and West Coast fresh, brackish, and marine locations identified in partnership with existing state or regional monitoring programs, shellfish restoration programs, and aquaculture companies in New York, Maryland, Virginia, and California. The project addresses critical knowledge gaps in the extent of microcystin contamination in marine bivalves and the optimal methods for quantification. Traditional and novel microcystin monitoring approaches in both bivalves and water samples will be evaluated for their collective suitability to detect microcystins in marine bivalves. This study will generate baseline information on the occurrence, prevalence, and concentrations of microcystins in bivalves, including environmental predictors of microcystin accumulation and depuration in bivalves.This information is needed to begin to manage the threat of microcystins in bivalves.

MERHAB: Portable Toxin Detection Technology to Support Great Lakes Decision Support Tools

Institutions: Bowling Green State University, LimnoTech, Inc., MBio Diagnostics, Inc., NOAA NCCOS, Ohio State University, University of Michigan Cooperative Institute for Great Lakes Research, University of Toledo

Project Period: September 2019 – August 2022

Location: Great Lakes

FY19 Funding: $408,371

Total Anticipated Funding: $876,843

Project Summary: This project improves the rapid detection of cyanotoxins in the field to provide managers with timely information on risk and minimize exposure to stakeholders. The project team will pilot use of a commercially-available rapid, portable system capable of quantitative detection of two cyanobacterial toxins, cylindrospermopsins and microcystins. This system will be integrated into existing monitoring programs that engage recreational beach managers, water treatment plant operators, charter boat captains, and state environmental scientists. The project team will concurrently evaluate and validate the system against the current 'gold standard' analytical method and determine the system's accuracy and sensitivity for detecting common microcystin congeners. End users will communicate results to the project team and selected resource managers in real time using a cell phone application. The rapid detection technology and improved monitoring strategies piloted in this project will prevent human exposure to contaminated drinking and recreational waters in western Lake Erie and in other similarly affected water bodies around the United States.

MERHAB: Application of Quantitative Molecular Methods to Characterize Abundance and Distribution of *Alexandrium* Cysts for NOAA's HAB Forecasting

Institutions: University of Washington Tacoma, NOAA NCCOS, University of Alaska Fairbanks, Alaska Sea Grant

Project Period: September 2019 – August 2022

Location: Pacific Northwest and New England

FY19 Funding: $227,241

Total Anticipated Funding: $562,209

Project Summary: This project develops two lab-based quantitative molecular methods for the detection and counting of *Alexandrium catenella* resting cysts in sediment from the Gulf of Maine, Washington (Puget Sound), and Alaska (Kodiak & Kachemak Bay). The project will develop a target-specific DNA probe for a fluorescent *in situ* hybridization (FISH) assay. The potential use of a previously developed quantitative polymerase chain reaction (qPCR) marker, designed for use in vegetative cells, will be tested for cyst detection and identification. Standard curves between microscopic-FISH methods and the qPCR method will be evaluated. These new methods will be validated against conventional microscopic identification and quantitation techniques. The molecular detection methods will reduce time and effort, and improve the accuracy of cyst counting and identification methods. Additionally, this project will transfer these methods to HAB researchers, monitoring organizations, and stakeholders. This work leverages past and current ECOHAB projects and benefits the NOAA HAB Operational Forecasting System. The project will provide a management-relevant tool to help stakeholders with rapidly planning and forecasting PSP-related HAB events using an existing NOAA platform in a cost and time effective manner.

MERHAB: Emerging Algal Toxins in the California Current System: Responding to Known Threats, Preparing for the Future

Institutions: University of California Santa Cruz, Central and Northern California Ocean Observing System, Central Valley Regional Water Quality Control Board, Lummi Nation, Northwest Indian College/Salish Sea Research Center), Southern California Coastal Ocean Observing System

Project Period: September 2019 – August 2023

Location: California and Washington / West Coast/ Pacific

FY19 Funding: $499,468

Total Anticipated Funding: $1,088,156

Project Summary: Surveys in California have highlighted the co-occurrence of multiple HAB toxin groups, but these are severely under-reported threats driven by interactions at the land-sea interface where freshwater and marine toxins mix. A more holistic approach to understanding and predicting HABs is a fundamental requirement for their monitoring and management. The project will evaluate the ability of the passive resin-based sampling method, Solid Phase Adsorption Toxin Testing (SPATT), to simultaneously measure multiple toxins in coastal environments, focusing on the California Current System (CCS). Common toxigenic HAB taxa in the region include *Pseudo-nitzschia*, *Alexandrium*, *Dinophysis*, *Akashiwo*, and *Microcystis*. The project will compare SPATT resin types and membranes; examine the effects of flow rates and binding kinetics; conduct field deployments for environmental sensitivity; and analyze historical (over 10 years) and current preserved SPATTs to evaluate multiple phycotoxins in the CCS ecosystem.The work builds upon previous NCCOS HAB projects and the PI team involves scientists from key California stakeholders. This project will engage diverse stakeholder groups by establishing a standard operating protocol that will make results applicable to a wide range of managers and monitoring within the region and across the United States.

MERHAB: Developing a Machine Learning-Based, High Resolution, Predictive Capacity for Monitoring Paralytic Shellfish Toxins Along the Gulf of Maine Coastline

Institutions: Bigelow Laboratory for Ocean Sciences, Maine Department of Marine Resources

Project Period: September 2019 – August 2021

Location: New England

FY19 Funding: $521,157

Total Anticipated Funding: $772,620

Project Summary:
Extensive blooms of *Alexandrium* occur in the Gulf of Maine each year and produce toxins that can accumulate in shellfish, causing Paralytic Shellfish Poisoning. Regional shellfish management agencies conduct rigorous monitoring activities to ensure the safety of shellfish consumers and support the shellfish industry. These stakeholders have requested forecasts of paralytic shellfish toxins (PST) in shellfish, targeted to specific stretches of coastline and bays in the region. The project will implement a machine-learning based forecast with high spatial and temporal resolution. Using historical shellfish toxin data from Bigelow Laboratory and the Maine Department of Marine Resources (DMR), this forecast predicted the onset and decline of shellfish toxicity in specific locations with > 95% accuracy one to two weeks in advance. The investigators will develop an automated data pipeline to generate a machine learning-based forecast from PST monitoring data for over 30 locations along the Maine coast. Past and current location-specific information and reports will be available to end-users via the internet. This project will develop, refine, and test products to communicate optimal shellfish production and harvest times, and early warning of changes in shellfish toxicity levels. The project will help agencies better mitigate the severe impacts disruptions from PST accumulation and related closures have on shellfish aquaculture and harvesting industries.

MERHAB: Expanding the Southeast Alaska Tribal Ocean Research Program for Monitoring of Amnesic Shellfish Poisoning and Diarrhetic Shellfish Poisoning

Institutions: Sitka Tribe of Alaska, NOAA NCCOS, NOAA Northwest Fisheries Science Center, Washington Sea Grant Program

Project Period: September 2019 – August 2022

Location: Alaska

FY19 Funding: $316,740

Total Anticipated Funding: $958,974

Project Summary: This project expands existing HAB toxin monitoring conducted by the Sitka Tribe of Alaska (STA) to include domoic acid and diarrhetic shellfish poisoning (DSP) toxins, and to validate the protein phosphatase assay (PP2A) compared to accepted methods for DSP toxins. STA runs a successful monitoring program for HAB toxins, which pose a health risk to subsistence, recreational, and commercial shellfish harvesters throughout Southeast Alaska. STA also promotes effective collaborations with HAB monitoring programs across Alaska and the Pacific Northwest region. There is evidence of sporadic occurrence of domoic acid and DSP toxins in Alaska waters, and Southeast Alaska may serve as a sentinel location to detect the northerly spread of these toxins known to occur regularly in Pacific Northwest coastal waters. Expanding STA's capacity to detect these emerging toxins in Alaska addresses a recognized gap in the existing monitoring framework and meets the MERHAB objective to build capacity for less costly and more precise and comprehensive monitoring of phytoplankton cells and algal toxins, and for responding to HAB events.The project addresses the need for cost-effective toxin detection for public health protection in remote regions. Key data collected in this project will aid method validation for the determination of DSP toxins in additional shellfish matrices and support the NCCOS priority to advance new detection technologies that provide states, municipalities, and tribal nations with the ability to identify and quantify HAB species and toxicity.