Florida Harmful Algal Bloom Task Force

Consensus Document #2:

Progress and recommendations regarding red tide (Karenia brevis) blooms

Draft: November 1, 2021

In 2019, the Florida Fish and Wildlife Conservation Commission’s Fish and Wildlife Research Institute (FWC-FWRI) reconvened the Harmful Algal Bloom (HAB) Task Force, and the HAB Task Force concentrated on issues associated with blooms of Karenia brevis, which was consistent with the Governor’s direction. On January 31, 2020, the HAB Task Force recommended several actions to improve our ability to manage red tide and its harmful effects in a “Consensus Document #1: Initial Recommendations Regarding Red Tide (Karenia brevis) Blooms.” The recommendations focused on Public Health, Communications, Management and Response, and Research.

In addition to recommendations, the first consensus document contained key background information, and this consensus document builds on the first with updates on action to address the initial recommendations. Furthermore, the HAB Task Force reviewed the initial priorities and identified additional actions that will advance management of red tide.

The HAB Task Force continues to recommend actions that create improved understanding of red tide and translate it into enhanced management. Like its predecessor, this document is not intended to provide an exhaustive list of useful actions, and its recommendations are meant to complement and support other efforts to set long-term goals and implement specific actions that minimize the harmful effects of red tide as well as a variety of other HABs that impact Florida, such as the work of the Blue-Green Algae (BGA) Task Force.

Background

The severity, duration, and spatial extent of red tide events caused by Karenia brevis vary widely from event to event. Blooms can persist through all seasons, tropical storms and hurricanes, coincide with other HAB events (spatially and temporally) in marine, estuarine, and freshwater systems, and result in widespread reports of fish, sea turtle, marine mammal, and other wildlife mortalities and human respiratory irritation. The scale of response needed for events vary and involve numerous agencies and partners, new strategies, and extensive communication efforts. There is a continued need for more intensive and comprehensive monitoring and event response capabilities that span blooms and their impacts. These efforts generate critical data necessary to document changes in bloom intensity and severity across time, and to better understand the complex mechanisms underlying bloom development, intensification, sustenance, and decline. There is also a continued need to document and better understand the fate and resulting impacts of toxins on human, wildlife, ecosystem, and socioeconomic health. Severity can be based on a diversity of metrics, and there’s an increased need to define and document severity over time, to look at drivers individually and holistically, and to do it in a systematic way to better facilitate such historical comparisons and corresponding model development to improve interdisciplinary forecasting and hindcasting.
capabilities. There’s also an ever-growing need to communicate results quickly and effectively across many domains, spanning management to the public. There are challenges and successes associated with all elements of monitoring, event response, and research, and each event provides novel insight that helps inform the implementation of new and existing tools, including those that may help mitigate the impacts or severity of HAB events in Florida.

**INSERT: Graphic Timeline**

Multiple events demonstrate progress since the HAB Task Force was reactivated. Key efforts relate to identified priorities, and they include complementary initiatives led by partners, such as the Center for Red Tide Research and the Florida Red Tide Mitigation and Technology Development Initiative.

**August 2019:** HAB Task Force reactivated
- Florida Red Tide Mitigation and Technology Development Initiative established with Mote Marine Lab (F.S. 379.2273)
- FWC-FWRI Center for Red Tide Research established
- Two public meetings of the HAB Task Force

**January 2020:** HAB Task Force endorses and supports the recommendations of the Blue-green Algae Task Force Consensus Document #1 and presents its own Consensus Document #1: Initial Recommendations Regarding Red Tide (*Karenia brevis*) Blooms
- Five public meetings of the HAB Task Force
- FWRI Center for Red Tide Research expands cooperative monitoring and research program for 5-years with Mote and USF
- Mote supports 12 red tide mitigation and technology projects
- FWRI HAB Grants program funds three projects: one red tide communications and two real-time detection projects
- HAB Communication Working Group is established

**2021**
- Red tide research facility opened at Mote
- Six public meetings of the HAB Task Force
- Florida HAB Monitoring and Observing Network Steering Committee established
- HAB Communications Working Group initiates action plan for statewide public communications based on proposed UF/Florida Sea Grant strategy

**December 2021:** HAB Task Force presents Consensus Document #2
The detrimental effects of the prolonged 2017-2019 red tide event in southwest Florida were felt across multiple counties, business sectors, and residents and tourists alike. Given the scope and duration of the event, final estimates of economic, ecological, and social impacts are still being calculated by various novel and ongoing studies. This significant occurrence provided the opportunity for researchers to develop innovative approaches to better capture just how much these events affect our lives.

Researchers are using new data and approaches in efforts to capture economic impacts from the 2017-2019 bloom on tourism related sectors (1,4). Forthcoming studies are attempting to capture multi-millions in lost expenditures by:

- tourists on accommodations, food and drink, event venues and equipment rentals in impacted counties,
- declines and cancellations of Airbnb property rentals, which in turn caused total economic impacts losses in industry output (sales revenue), total value-added, total labor income, total federal, state, and local tax impacts; and job-years lost.

Another study aiming to estimate impacts on boaters investigated the costs and losses to boaters that were forced to make alternative arrangements found that boat ramp closures in Lee County from the end of June to the end of September in 2018 resulted in a lost value to boaters of $3 million due to the need to find alternative boating access (2).

People also value the wildlife that is supported by a healthy coastal ecosystems. When red tides kill fish and wildlife, people are negatively affected. A recent study that utilized recently estimated public values for dolphins, manatees, and sea turtles found that marine animal deaths from red tide in Southwest Florida represented a lost value of nearly $200 million; this is the lost value experienced by citizens for the damage caused to these resources (3). Additionally, the profound loss of animal life in coastal habitats directly affected the commercial fishing industry.

A new vein of research aims to use social media activity to better understand people’s concerns and to ascertain the extent to which social media content either amplifies or attenuates the effects of HABs on residents (5,6). Other studies are attempting to detail far-reaching effects of red tide such as community declines in health and happiness associated with the prolonged red tide (5,6).

Finally, it takes resources to prevent economic losses when blooms escalate. During the peak of the bloom in 2018, counties were awarded nearly $10 million in FDEP grant funds to reimburse the costs of cleanup for contractors, rental equipment, disposal fees, and overtime hours for regular employees (5,6). Cleanup efforts resulted in:

- 255 tons of red tide debris removed from Sarasota County beaches and boat launches.
o 316 tons of red tide debris removed from Manatee County beaches, bay causeways, boat ramps, and some inshore bays.

o 1,862 tons of red tide debris removed from Pinellas County waters following an intensive effort to detect, prioritize, and harvest dead fish offshore and inshore to try to minimize the onshore impact to beaches and coastal marsh.

The lack of a systematic approach for quantifying economic losses precludes rapid or accurate assessments on the economic impacts of these types of devastating events and is an ongoing need.

References


HAB Task Force Recommended Actions

Red tide and other harmful algal blooms create a complex set of ongoing challenges. The HAB Task Force sees considerable value in a long-term vision paired with significant and sustained investments that reduce risks to public health (PH), ensure successful communication (C), and employ adaptive management and response (MR) strategies. Investments are more likely to yield societal value if they are based on research (R) that fills gaps in knowledge and increases understanding. The vision and investment should include complementary and interconnected actions because no single or isolated effort will suffice. Adaptive management allows us to cope with inevitable uncertainty by assessing effectiveness and making prudent adjustments. Furthermore, some investments will yield value in the short term, whereas others will require more time to yield optimum return.

The Task Force and its partners have addressed the recommendations in the 2020 consensus document (P1–P10 in the appendix). Based on this progress and more deliberation, the HAB Task Force recommends the following actions.
Public Health (PH)

Public health includes the physical, social, and mental health of residents and visitors; safe recreation opportunities and working conditions; consumption of safe seafood; and protection of their companion animals and domesticated animals. Public health sustains the quality of life for people in Florida and makes the state an attractive and safe place to live and work.

Provide DOH with resources needed to make multiple improvements in protection of public health.

- DOH should collaborate with professional health associations to develop a training program for the state’s health care professionals that improves diagnosis, treatment, and reporting of red tide- and other HAB-related illnesses. (PH, C) – Progress icon P1

- DOH and relevant partners should develop guidelines and related training that will protect the health of people who work near blooms regularly. (PH, C)

Public Health Research

- DOH should take the first steps toward creating a framework that minimizes harm from red tide by identifying and prioritizing unknowns related to short-term and long-term health problems caused by brevetoxin and seeking collaborators and resources to work towards eliminating those gaps in our knowledge. (PH, R) – Progress icon P2

DOH will coordinate with experts and stakeholders, and an updated Resource Guide for Public Health Response to Harmful Algal Blooms in Florida will support the training.

The effects of long-term and repeated exposure to blooms are not well known, and they may create a need for protective equipment or protocols to prevent illness.

Exposure to brevetoxin includes contact with skin, swallowing, and inhaling, and the framework should address pathways for exposure, risks of disease, and strategies to minimize harmful exposure.
Communications (C)

Communications refers to free movement of information among diverse stakeholders to encourage them to support key actions and engage in behavior that minimize the detrimental effects of blooms. Communications incorporate productive interactions among those with responsibilities related to red tide, timely and targeted responses that protect people and ecological systems without causing undue anxiety, education that is accessible and easy to understand, and feedback that ensures accountability and leads to improvements.

Provide the HAB Communications Working Group with the resources needed to take key actions that improve communications about red tide and other HABs.

- The HAB Communications Working Group should build on recent evaluations of existing communications to develop and begin to employ a strategy and associated tactics that enhance alerts and education related to red tide and other HABs to enhance public awareness and minimize harm. (C, PH, MR) – Progress icons P3, P4

- DEP, FWC, DOH, the HAB Communications Working Group, and other partners who respond to red tide should build on the “Protecting Florida Together” dashboard and other trusted sources of information to convey the status of HABs more effectively, efficiently, and comprehensively so that people can access the information they seek. (C, PH, MR)

Communications Research

- The HAB Communications Working Group should collaborate with experts to develop a program that will evaluate the short-term to long-term outcomes of communication as a guide for future improvements. (C, R)

The working group will coordinate experts and stakeholders, and the strategy will outline actions to 1) identify hazards, convey risks, and deliver alerts; 2) being a long-term campaign to increase awareness, understanding, and safe behavior across all age groups and demographics; 3) create and maintain a repository of shared resources that promote accurate and consistent messaging; and 4) seek feedback to guide improvements.

Recent evaluations suggest that a network of websites is needed to provide timely, accurate, and comprehensive information on the status of HABs, with multiple levels of detail tailored to different groups of stakeholders.

Ongoing evaluations are critical to verify the effectiveness of communication and change approaches as audiences gain awareness and understanding.
Management and Response (MR)

Management and response seek to minimize the harm caused by algal blooms, which will remain an ongoing need because algal blooms will continue to occur. Management and response include detection of blooms, assessment of hazards and risks, issuing of suitable warnings, actions that prevent or alleviate detrimental effects, and evaluation and revision of all efforts.

Provide the HAB Task Force and state management entities, and other relevant groups with the resources needed to reduce harm from red tide and other HABs.

- FWC, DEP, DOH, DACS, local governments, and other partners and stakeholders should review current practices and develop a comprehensive response plan supported by monitoring and streamlined permitting for control and mitigation. (MR, C) – Progress icons P1, P5, P6

- FWC, DEP, DOH, DACS, water management districts, partners in the integrate ocean observing system, local governments, and other stakeholders should review and document current practices to detect red tide and other HABs, opportunities for improvement, and resources required to provide earlier and more accurate warnings. (MR, R, PH, C) – Progress icon P7

- DEP should streamline permitting for testing and applying technologies to control or mitigate red tide and other HABs. (MR, R, C) – Progress icon P6

The response plan should address 1) tiers of routine and event-driven monitoring; 2) communication during emergencies that links federal, state, and local groups; 3) triggers for issuing warnings, initiating control, commencing mitigation, and taking other actions that can be tailored for localities and affected industries; 4) best practices that define roles and responsibilities; and 5) resources needed and ways to garner them.

Ultimately, monitoring should 1) span freshwater, estuarine, and marine locations where HABs occur; 2) track and assess loads and cycling of nutrients that fuel HABs; 3) assess the effectiveness of efforts to manage those loads; 4) provide early warning of HABs; and 5) draw on emerging technologies to enhance detection and tracking of algal cells and toxins in water, air, and seafood.

Key considerations include benchmarks for development and testing, special needs during a state of emergency, federal limitations, and requirements specific to large-scale efforts.
Nutrients play a necessary role in the environment; however, excessive nutrients can cause an imbalance. This imbalance is evidenced by increased frequency, duration, and intensity of HABs in Florida that are negatively impacting the ecosystem, economy, and public health.

Knowing how nutrients feed HABs will provide a better understanding of how blooms form, grow, and eventually die. Identifying how nutrient inputs and nutrient recycling affect blooms both offshore and nearshore is a complex issue and continues to be a research priority of the HAB Task Force who understands that reducing nutrient loads to our freshwater and coastal systems is essential for management of HABs and lessening the intensity and duration of red tide blooms once they move inshore. The HAB Task Force recognizes that reducing Florida’s nutrient enrichment problem is a priority and will require improvements to existing regulatory programs and implementation of new and innovative nutrient management programs.

The BGA Task Force’s Consensus Document #1 included numerous recommendations to reduce nutrient loads to surface and groundwaters. These recommendations were utilized to develop Florida’s Clean Waterways Act of 2020. The HAB Task Force supports the efforts of the BGA Task Force to ensure that the legislative efforts put forth in the Clean Waterways Act are enacted and ultimately achieve the goals of nutrient load reduction and improve water quality. We support efforts to verify and improve the effectiveness of Total Maximum Daily Loads, Basin Management Action Plans, stormwater permitting, agricultural best management practices, and the prevention of nutrient discharges associated with human waste. As research continues to fill knowledge gaps and identify specific nutrient sources that are feeding harmful algal blooms, the BGA and HAB Task Forces will work together to prioritize nutrient management recommendations and needs.
Management and Response Research

- FWC, DEP, DOH, DACS, DEO, and other partners and stakeholders should engage with scientific, health and economic specialists to improve and standardize evaluations of the severity of red tide and the broad socioeconomic impacts from blooms across years. (MR, R)

- FWC, with existing and new partners, should document and build on available information to design investigations that will yield an understanding of red tide sufficient to guide effective and adaptive management. (MR, R) – Progress icon(s) P7

- FWC, with existing and new partners, should develop a suite of models that predict the initiation, progress, and termination of *K. brevis* blooms and their impacts so early warnings can be evaluated and potential improvements to management can be evaluated. (R, MR, PH) – Progress icon(s) P7, P8

- FWC, with existing and new partners, should foster projects that will improve early detection of *K. brevis* and brevetoxins to enhance rapid response. (R, MR, PH) Progress icon(s) P8, P9

- The Red Tide Mitigation and Technology Development Initiative and other partners should continue to evaluate strategies and approaches to control blooms and mitigate their detrimental impacts. (R, MR) Progress icon(s) P10

This information is needed so that long-term trends and progress in reducing bloom impacts can be evaluated. The approach should include a set of rigorous and comparable methods, tools, and metrics, which are based on currently available information whenever possible.

The program should include large-scale, long-term, cross-shelf surveys, and it will require consistent and sustained funding over multiple years to address factors that initiate red tide and control bloom dynamics in coastal and offshore waters.

These tools are needed so that early warnings can be generated and potential improvements to management can be evaluated. Models should address short-term (days) and long-term (seasonal) dynamics of blooms, onshore and inland transport of brevetoxins in air, and the roles of nutrient inputs, nutrient cycling, and climate change in exacerbating blooms and their impacts.

The goal is to detect *K. brevis* in water and brevetoxins in water, air, and seafood rapidly and accurately.

Evaluations require sustained funding to ensure the strategies evaluated are rigorous and cover multiple temporal and spatial scales.
The HAB Task Force recommendations address immediate needs to better understand and minimize the negative effects of red tide on Florida’s residents and visitors. In the future, the HAB Task Force will address other HAB species and events impacting Florida coastal waters. Without hard work and careful planning, the challenges created by HABs are likely to worsen due to the influences of other environmental stressors associated with climate change and Florida’s growing population.

Scientific research suggests that the impacts of climate change may promote HABs through a complex variety of mechanisms including warmer water temperatures, changes in salinity, changes in rainfall patterns, increased atmospheric carbon dioxide concentrations coastal and ocean acidification, changes in coastal upwelling, and sea level rise. The State of Florida has made historic investments to better understand coastal vulnerabilities and recommend actions to build resilience in both natural and human communities. Some large-scale climate trends may be impossible to change, but continuing investments made by the state to build coastal resilience in our communities is an important first step. Partnerships and coordinated actions among all Floridians will be essential to success. In addition to the immediate benefits provided by development of innovative strategies to managing red tide blooms and their impacts, the actions we take now can decrease community vulnerability and build resilience in our coastal infrastructure. A comprehensive and strategic approach to address the issues will strengthen the economic resilience of Florida’s human-built infrastructure, nature-based economy, and the ecological resilience of our diverse coastal ecosystems. Investments made today will deliver significant return on investment in the long run.

**INSERT BOX: Federal investment in *Karenia brevis* research and response**

The federal investment addressing the problem of *Karenia brevis* blooms in Florida has a long history. Appendix B includes a list of current and recent projects funded by federal agencies. Most have been funded by various offices and programs in the National Oceanographic and Atmospheric Administration (NOAA). Other federal agencies supporting current *Karenia* research include the National Institute of Health National Institute of Environmental Health (NIH NIEHS), and the Centers for Disease Control and Prevention (CDC). These projects build on a long history of prior efforts by federal agencies to understand, predict, and monitor *Karenia blooms* and its toxins, dating back to the late 1940’s, and intensifying in the 1990’s.

**Investing in Red Tide Monitoring, Response and Mitigation**

The State of Florida is making historic investments to manage harmful blooms of *Karenia brevis* that include improved detection, enhanced responses, effective control, prudent mitigation, and increased understanding of bloom dynamics. The Florida Harmful Algal Bloom/Red Tide Task Force is dedicated to providing scientific support to guide those investments. The HAB Task Force recognizes that Florida’s HAB and water quality problems are big and complex. Solutions will require long-term dedicated investments for projects, focused programs, facility support, and expansion of experienced and dedicated program staff to effectively respond to growing challenges and needs.
Algal blooms are part of health and productive coastal and ocean ecosystems. However, when conditions are right, algal blooms can become intense, long-lasting, expansive, and sometimes toxic to both wildlife and humans. When this happens, HABs become a threat to wildlife, people, our coastal economy, and our quality of life. One example of a Florida tourism industry sector that is directly vulnerable to HABs is saltwater recreational fishing. In Florida this industry generates an estimated $9.2 billion annually and employs 88,501 people (American Sportfishing Association and Southwick Associates, based on USFWS 2011 survey data updated to 2020; FWC 2021). HABs threaten the future of this industry and Florida’s global brand as the “fishing capital of the world.”

Nutrient over-enrichment is an important factor that can drive increased severity and frequency of HABs in coastal waters. Florida is addressing these problems with a historic and comprehensive “all hands on deck” approach. Scientists are working throughout the state and nation to better understand the complex physical, chemical, and biological factors that combine to initiate, sustain, and terminate red tide blooms.

Solutions will require multiple approaches because nutrient enrichment comes from long-term, low-level, diffuse inputs, as well as major events associated with aging, inadequate, and vulnerable wastewater and stormwater infrastructure. On recent example is the discharge of approximately 215 million gallons of process water and 205 tons of total nitrogen from the Piney Point gypsum stack into Tampa Bay in 2021. That increased nutrient load fueled algal blooms in the waters of lower Tampa Bay and may present long-term challenges to estuary restoration that are still not fully understood.

To complement solutions to the nutrient problem, the Florida Red Tide Mitigation & Technology Development Initiative (a partnership between Mote Marine Laboratory and the FWC) seeks to develop technologies for HAB prevention, control and mitigation that decrease the impacts of red tide on the environment, economy, and quality of life in Florida. This coordinated effort among public and private research entities brings together the best and brightest scientists from Florida and around the world, attracted by world-class research facilities funded by Governor DeSantis and the Florida Legislature in 2019. Much has been learned since the start of the initiative. The HAB Task Force is looking forward to the emergence of innovative strategies from this initiative that will lessen a variety of HAB risks.

In summary, Florida is making progress, but much work remains. Problems will not be solved by a single “silver bullet.” Instead, community leaders, industry leaders, regulators, policy makers, scientists, and citizens must resolve to work together on delivering a portfolio of innovations, science-based policy decisions, and financial investments that ensure Florida remains a world-class destination to live, work, and play.
Long-term Focal Areas

The HAB Task Force has adopted broad, long-term focal areas within which it will evaluate existing approaches or knowledge; pinpoint gaps in our efforts or understanding; and build a prioritized portfolio of strategies and actions to fill those gaps by assessing their benefits and feasibility. The HAB Task Force will prioritize and recommend:

- actions to reduce excess loads of nutrients entering our freshwater and coastal systems developed in collaboration with the Blue-Green Algae Task Force, relevant entities identified in Executive Order 19-12, and other stakeholders;
- improvements to current policies and procedures that prevent or mitigate the impacts of harmful algal blooms on public health, ecosystem sustainability, economic viability, and other valued facets of society;
- enhancements to communication, coordination, cooperation, and collaboration among stakeholders charged with responding to harmful algal blooms and their effects; and
- strategic research into the biology and ecology of species creating harmful algal blooms; detection, tracking, modeling, and prediction of blooms; fate of algal toxins; impacts of blooms on valued facets of society; prevention, control and mitigation of blooms; and other key issues.
Appendix A

The following initiatives and activities address the initial recommendations of the HAB Task Force.

P1) Resource Guide for Public Health Response to HABs in Florida

The Resource Guide for Public Health Response to Harmful Algal Blooms in Florida, was originally developed in 2009 to support the HAB Task Force’s legislative mandate (F.S. 379.2271). The report expanded on and updated information identified in the Task Force’s 1999 white paper Harmful Algal Blooms in Florida. In addition, it provided technical information and presented a methodology to help state and local government and county health departments develop integrated public health environmental monitoring response plans to HABs. The reinstated HAB Task Force identified the need to update the guide to reflect current knowledge and practices in HAB science and management, and a 2021 edition has since been published. This user-friendly resource guide has two major components. The first provides background information to guide the development of local response plans and quick reference guides for responses to public health threats from HABs. The second component presents a method for developing flowcharts and further technical information related to responses to HABs. The guide will be reviewed regularly and updated to incorporate new information and materials that facilitate the development of local response plans.

P2) DOH HAB-health initiatives

In 2020-21, $1 million was appropriated by the legislature to the DOH for projects aimed to improve management of long-term health impacts from cyanobacteria and K. brevis. The DOH established a HAB-health working group in 2021 to identify research needs and associated improvements to surveillance, reporting, and education. The DOH, with partners and stakeholders, have been developing information and tools needed to effectively address recommendations from the working group and the HAB Task Force.

P3) HAB Communications Working Group

The HAB Communications Working Group resolves issues surrounding communication about HABs. It achieves this goal by tackling barriers to effective communication as identified by the HAB Task Force and state agencies, providing input on initiatives funded by the FWC-FWRI HAB Grant Program or other sources, and guiding development of statewide communication plans and long-term educational campaigns to better inform the public about HABs. The working group has members from government agencies, academia, industry, and non-governmental organizations, and it is coordinated by FWC-FWRI and co-chaired by two members of the HAB Task Force. In 2020–21, the working group identified and began to work on a set of priorities. It developed a list of first points of contact for questions regarding HABs, and that list will be distributed to stakeholders who field calls from the public. The working group began and will continue a review of answers to frequently asked questions conveyed to the public through various means, and it will review a report describing a long-term strategy for multi-lingual and
multi-modal communication about red tide to be delivered by the University of Florida/Florida Sea Grant.

**P4) Developing a communications plan for red tide in Florida**

The FWC-FWRI HAB Grant Program funds projects that address priority recommendations of the HAB Task Force. In 2020-21, funding was awarded to UF/Florida Sea Grant to advance red tide communications. The project conducted focus groups and social science studies to identify red tide information needed by the public and the most effective models for messaging and dissemination. In September 2021, a final framework was proposed to the HAB Communications Working Group that aligns practitioner needs with end-user wants. Anticipated benefits of the red tide communication plan include improved understanding of red tide and increased access to timely information to mitigate health risks, protect the economy, and instill confidence in Florida’s red tide monitoring and management. These benefits will arise from clear, credible, coordinated, and consistent messaging through appropriate methods accessible to diverse audiences. This project will result in a framework for implementing a multimodal, multilingual, coordinated statewide communication plan for red tide.

**P5) FWC Center for Red Tide Research**

The FWC Center for Red Tide Research provides the backbone to both enhance existing partnerships and develop new ones, bringing together state and local government, university, private sector partners, and citizen scientists to enhance statewide red tide monitoring and conduct applied research. Various projects that address specific recommendations of the HAB Task Force associated with tracking, predicting, and mitigating effects of red tide were initiated in 2020-21 and continued efforts are underway to further address next steps and priorities in 2021-22. These include more than 14 interdisciplinary research projects focused on advancing technology for monitoring and observational datastreams (including cells, toxins, nutrients, and impacts).

**P6) DEP HAB initiatives**

The DEP Division of Water Resource Management has drafted and provided FWC, Mote, and other stakeholders with draft Non-Point Source Discharge Elimination (NPDES) permit language related to a Generic Permits for the application of red tide mitigation products that qualify as pesticides. The Generic Permit conditions outline the informational needs and conditions that must be met by the permittee and will speed up the process of obtaining DEP permitting approval during red tide mitigation pilot projects in waters of the state. In addition to the draft Generic Permit language, the DEP continues to develop, improve, and expand the Protecting Florida Together website to better assist the public and stakeholders with finding red tide-related information, regardless of which state agency is responsible for producing its content.

**P7) Florida HAB Monitoring and Observing Network Steering Committee**

In response to both the need to design and implement a robust, statewide, integrated coastal and ocean monitoring and observation system that feeds into a suite of existing and future
predictive models that deliver value to multiple stakeholders, a steering committee was established to plan a workshop. The committee consists of seven members, including state and federal representatives and members of both SECOORA and GCOOS, the two IOOS Regional Associations in Florida. The workshop being planned for 2022 will build awareness across the research and stakeholder communities regarding new and existing data streams; new or collective assets; comprehensive consideration of impacts; gaps in knowledge, data, or technology; the short-term and long-term need for expanded modeling and technology; methods to convey risks effectively, approaches to improve management of ecosystem and public health; and the value of a tiered approach to funding.

P8) Field deployable measurement of aerosolized brevetoxins from *Karenia brevis* using colorimetric immunoassay

The FWC HAB Grant Program funds projects that address priority recommendations of the HAB Task Force. In 2020-21, funding was awarded to the University of Florida to advance real-time detection of red tide toxins. The project aims to develop a field-deployable colorimetric immunoassay that measures aerosolized brevetoxins. In the first year of the project, investigators developed and tested two methods of aerosol sampling that are faster and simpler than the high-volume air samplers traditionally used. A novel enzyme-linked immunosorbent assay based on magnetic nanoparticles is being optimized. The project lays the foundation for development of a field-deployable tool for monitoring aerosolized toxins during red tide blooms and explores how long brevetoxins remain in aerosols and how they are degraded over time. This project will result in an improved ability to keep communities informed and implement effective responses to reduce impacts of red tide on public health.

P9) An in situ holographic imaging system for measuring distributions of *Karenia brevis*

The FWC HAB Grant Program funds projects that address priority recommendations of the HAB Task Force. In 2020-21, funding was awarded to Florida Atlantic University to improve real-time detection of red tide in water. To date, the project has achieved the following: 1) demonstrated the ability of digital holography to image *K. brevis*, 2) successfully tested the AUTOHOLO system as a means of documenting distributions of *K. brevis* populations in three dimensions, and 3) developed a database of over 22,000 *K. brevis* images for training convolutional neural networks to automate detection and classification. This novel imaging technology could improve in situ, real-time detection of *K. brevis* and interactions with associated communities via horizontal towing, vertical profiling, and/or deployment at a fixed location.

P10) Florida Red Tide Mitigation and Technology Development Initiative

In 2019, Florida Statute 379.2273 was signed into law, and it established the Florida Red Tide Mitigation and Technology Development Initiative as an independent and coordinated effort among public and private research entities. Approximately $3 million a year for six years is appropriated to FWC-FWRI and awarded to Mote Marine Laboratory to lead the development of innovative technologies and approaches that are critically needed to address the control and mitigation of red tide and its impacts. Since 2019, a state-of-the-art research facility was constructed to safely test tools for mitigation and over 25 projects involving more than 20
private business, government, and academic partners are examining over 125 potentially useful compounds in work that will proceed from lab to mesocosm to coastal waters.
### Appendix B Federal Investment

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<td>CRP, Competitive Research Program</td>
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<td>NIH NIEHS, National Institute of Health National Institute of Environmental Health Sciences</td>
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<td>NOS, NOAA National Ocean Service</td>
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Acknowledgements

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References

