FLORIDA RED TIDE MITIGATION AND TECHNOLOGY DEVELOPMENT INITIATIVE 379.2273(2)(d)

ACCOMPLISHMENTS AND PRIORITIES REPORT

JANUARY 2021

Red tides, or red tide harmful algal blooms, are a higher-than-normal concentration of microscopic alga that occur in ocean and coastal waters. Red tides in Florida have been documented since the 1800's and their impacts likely date back earlier, based on records from Spanish explorers. In Florida, the toxin producing *Karenia brevis* is the species causing most red tides. These blooms can harmfully affect sea life, lead to massive fish kills, cause human respiratory problems, close beaches, and determinately impact shellfish, fishing, hotel, restaurant, recreational, and tourism industries.

This report is being provided to meet the requirement of 379.2273(2)(d) Florida Statutes, which states: "Beginning January 15, 2021, and each January 15 thereafter until its expiration (2025), the initiative shall submit a report that contains an overview of its accomplishments to date and priorities for subsequent years to the Governor, the President of the Senate, the Speaker of the House of Representatives, the Secretary of Environmental Protection, and the Executive Director of the Fish and Wildlife Conservation Commission."

MITIGATING RED TIDE IMPACTS FOR FLORIDA

The Florida Red Tide Mitigation & Technology Development Initiative is a partnership between Mote Marine Laboratory (Mote) and the Florida Fish and Wildlife Conservation Commission (FWC) codified under 379.2273 Florida Statutes that establishes an independent and coordinated effort among public and private research entities

to develop prevention, control and mitigation technologies and approaches that will decrease the impacts of Florida red tide on the environment, economy and quality of life in Florida.

Governor DeSantis signing the Initiative Bill in 2019.

STATE OF FLORIDA RED TIDE RESEARCH PROVIDING LOCAL CONTROL OPTIONS

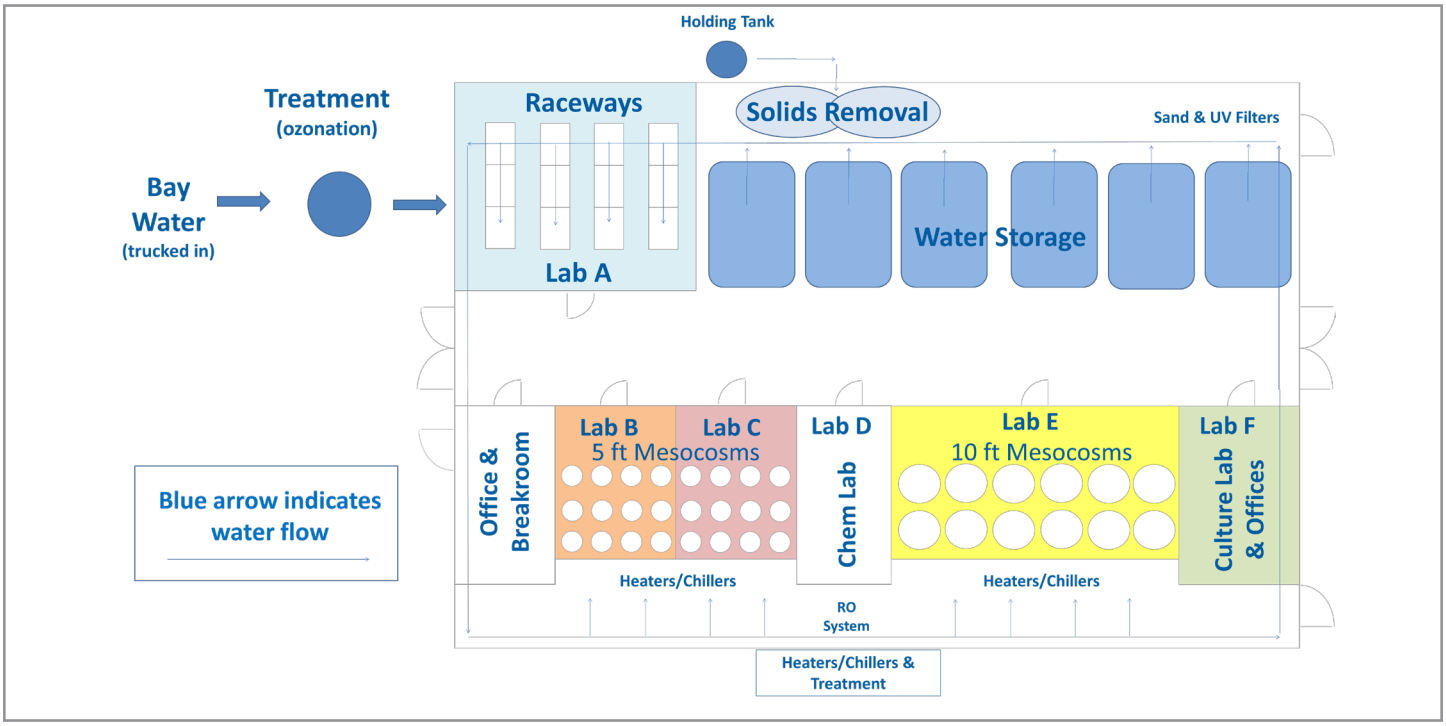
Mote is a 65-year leader of independent, entrepreneurial and nonprofit marine research and FWC's Fish and Wildlife Research Institute is the primary state-government entity focused on red tide. This Initiative builds upon the ongoing and highly productive FWC-Mote cooperative red tide research and monitoring program, while also leveraging state appropriations of $3-million each year for six years ($18-million total) with Mote's ability to secure additional private and federal funding in order to:

- Bring together the best and brightest scientists from Florida and around the world;
- Utilize innovative approaches and technologies to determine the most effective and ecologically sound methods for mitigating adverse impacts from red tide;
- Test technologies with combinations of lab-based, large-scale mesocosm and pilot-scale field studies ultimately leading to permitting for large-scale field testing and application;
- Develop novel detection systems to support public red tide forecasting, emergency response, and implementation of control strategies;
- Enhance public health protection with expansion of the Beach Conditions Reporting System (visitbeaches.org), local community outreach and engagement; and
- Develop new technologies for smartphone apps to engage citizen science information collaborations and commercial fisherman reporting of red tide toxin concentrations.

PIONEERING RED TIDE TECHNOLOGY TESTING FACILITIES

A key part of furthering red tide research was the need to safely test coastal ecosystem components with mitigation compounds and technologies through a tiered approach (lab based, mesocosms/raceways, then offshore) using red tide culture. Thus, Mote created a cutting edge experimental facility at the Mote Aquaculture Research Park (MAP) in Sarasota, approximately 15 miles inland from the coast. The facility uses almost 150,000 gallons of treated and recirculated seawater stored in large holding areas for research raceway tanks and 5-foot and 10-foot mesocosms. The facility and unprecedented quantities of *Karenia brevis* culture are free for initiative scientists, allowing for safe and controlled setting tests prior to pilot field implementation.

New facility partner signage.



Schematic of Mitigation and Technology Development Facility

New Facility Entrance

Research Raceways

5-foot Mesocosms

Culture Room

TECHNOLOGY ADVISORY COUNCIL

Mote has conducted three Technology Advisory Council Meetings in compliance with 379.2273(3) which states: "There is established within the initiative the Initiative Technology Advisory Council, an advisory council as defined in s. 20.03(7), that includes marine science, technology development, and natural resource management representatives from governmental entities, private organizations, and public or private research institutions. The council shall meet at least twice annually."

These public meetings have provided overviews of the administrative structure developed to run the initiative, public records laws, projects underway, proposals being considered, and planned next steps. Short biographies of the council members and presentations and meeting minutes from the January 17, April 3, and October 2, 2020 meetings are all on the Mote Red Tide Initiative website (www.mote.org/redtideinitiative).

Council Members include Dr. James Powell, Dr. Michael P. Crosby, Dr. Katherine Hubbard, Dr. James Sullivan, and David Whiting.

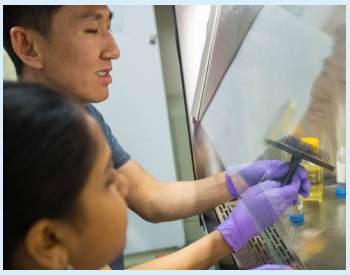
LEVERAGING WITH PRIVATE AND FEDERAL FUNDS

In accordance with 379.2273(2)(c)(3) which states: "The initiative shall leverage state-appropriated funds with additional funds from private and federal sources", Mote has successfully synergized and expanded initiative funding capabilities in numerous instances. For example, Mote has leveraged initiative appropriations with a generous donation from the Andrew and Judith Economos Foundation for numerous mitigation compound studies, funding from the Southeast Coastal Ocean Observing Regional Association to support initiative reporting technology improvements, and combined competitive USDA and NOAA grants as part of the initiative shellfish biosensor research.

SUMMARY OF EARLY INITIATIVE PROGRESS

- Statutory, Administrative, FWC Contract, and Partner Subcontract Structure
- Red Tide Mitigation and Technology Development Website
- Cutting-Edge Tide Research Facility
- **20+ Initiative Projects Underway**
- **Examining of Over 100 Potential Mitigation Compounds for Tiered Testing**
- **Strategic Selection of Tools to Fast Track**
- Public Technology Advisory Council Meetings
- Leverage Initiative Funding With Private and Federal Sources
- Overview Report of Progress to Date
- Preparations for 2021 Request for Proposals

INITIATIVE 2021-2025 NEXT STEPS



Expand and Expedite Lab Trials

Mesocosm Testing (Large Controlled Setting)

Regulatory Approvals and Field Testing

Further Public Engagement and Offshore Implementation

MOTE RED TIDE EXPERTISE AND PROJECTS

Mote brought together an experienced team of field and laboratory ocean and coastal scientists and resource management experts to lead Florida harmful algal bloom science and guide the initiative work. Mote utilized its in-house decades of red tide monitoring and innovative control techniques and pulled in valuable expertise from the private, academic, and public sectors to work collaboratively while expanding and strengthening the red tide scientific network. Over the past year, Mote's independent organizational framework has successfully navigated many challenges including hurdles from the COVID-19 pandemic in progressing initiative science while also incorporating training for the next generation of scientists via undergraduate internships, graduate fellowships, and postdoctoral opportunities.

Top: Mote red tide scientists in the lab.
Bottom: Mote red tide scientists offshore.

Initiative funding has allowed Mote to continue and expand the vital testing of mitigation products to find those that kill the algae, minimize the impact of the *Karenia brevis* toxin, and have no further human health or ecological harm. Mote has begun testing a variety of natural and manmade compounds, checking dosing rates, and examining the effects on the ecosystem (seawater, seagrass, crabs, shrimp, etc.) through a tiered approach from the lab to mesocosm to coastal waters. **Mote has examined over 100 chemicals and compounds, and early results are promising on numerous mitigation options for expanded testing.**

Mote also recognized the need in the early part of the initiative to develop shellfish and seawater field biosensor technologies, update automated seawater and phytoplankton community reporting equipment, and expand web and smartphone public interaction tools. These technology developments will reduce the time needed to quarantine shellfish and reduce consumer risk, effectively target mitigation efforts, and simplify and verify public communications. Over the past year, Mote has conducted pilot tests on clams and oysters for the biosensor, made significant progress in updating the Programmable Hyperspectral Seawater Scanner, re-tooled unmanned aerial systems for near-shore red tide reporting, and updated the Beach Condition Reporting System app. These tools will work in concert with local, state, and federal reporting systems to quickly disseminate information for mitigation and control of red tide blooms and inform residents, businesses, and visitors.

Mote led projects include:

- Seawater Scanner
- Phytoplankton Libraries
- Manmade Compounds
- Clay
- Algicides
- Shellfish Biosensor
- Unmanned Aerial Systems
- Public Beach Conditions Reporting
- *K. brevis* Polymerase Chain Reaction ID
- Quaternary Ammonium Compounds
- Bacterial Community Studies
- Polymer Coated Nanoparticles

RESEARCH PARTNERSHIPS & PROGRESS

Another important part of the initiative was included under 379.2273(2)(c)(1), which states: "Mote Marine Laboratory may, with the concurrence of the Fish and Wildlife Research Institute, use a portion of the awarded funds to facilitate additional engagement with other pertinent marine science and technology development organizations in this state and around the world to purse applied research and technology for the control and mitigation of the impacts of red tide." Mote embraced this opportunity with the careful guidance to partners that any developed mitigation technology must not cause greater harm to human health or the Florida coastal ecosystems than the red tide itself.

So far, Mote has conducted two Request For Proposals and review processes, advertised the initiative at many conferences and meetings, hosted two webinars, and led countless video/phone calls which ultimately have generated almost **50 partner-led mitigation technology development proposals**. The initiative funding opportunities have been open to any and all interested parties and Mote has received widespread local, state, national, and international interest.

Mote convened two highly qualified research proposal review panels composed of representatives from multiple federal and state agencies, several universities and Florida National Estuary Programs. The use of MAP red tide technology testing facilities at no charge was encouraged, but not required, and subcontracts were limited to 12 months (with ability to apply each subsequent year depending on previous year outcomes) to expedite and better guide research findings. A select group of proposals has been presented at the Technology Advisory Council meetings for recommendations and have been open to public comment.

Mote has subcontracted with **15 different private business and academic partners**, as demonstrated by their logos below:

Partner led projects include:

- Algicides
- Beer Derived Flavonoids
- Metal Phenolic Networks
- Clay
- Activated Carbon
- Cultured Microbes
- Removing and Composting Fish Carcasses
- Ultraviolet Light
- Light Sensor and Harvesting Robotic Vessels
- *K. brevis* Bacterial Community Studies
- Polymer Coated Nanoparticles

A complete list of project titles, principal investigators, and summaries are attached as an appendix to this report and can also be found on the Mote Red Tide Initiative website (www.mote.org/redtideinitiative) under the Partner Institutions link.

APPENDIX

FLORIDA RED TIDE MITIGATION AND TECHNOLOGY DEVELOPMENT INITIATIVE PROJECT EXECUTIVE SUMMARIES

Title: Development and Validation of New and Existing Technologies: Expanding PHySS's (Programmable Hyperspectral Seawater Scanner- PHySS(2.0)) Role in Mitigation of Harmful Impacts Caused by the Florida Red Tide
Principal Investigator: S. Chakraborty (Mote Marine Laboratory)
Co-principal Investigators: R. Pierce, G. Kirkpatrick, V. Lovko, J. Hillier, K. Henderson, and J. Turner (Mote Marine Laboratory)
Project Date: January 2020 - June 2021
Summary: This project is continuing development of the PHySS, which performs automated sampling and analysis of seawater and measures spectral absorption which is related to ancillary photopigments unique to *K. brevis*. The project is completing a hyperspectral library for different phytoplankton functional types, refining the algorithm by performing sensitivity and uncertainty analyses, and calibrating and validating PHySS on other platforms such as AUVs (gliders), field sampling, and remote sensing data.

Title: Beach Conditions Reporting System
Principal Investigators: K. Claridge (Mote Marine Laboratory)
Co-principal Investigators: R. Pierce, S. Caywood, and A. Cook (Mote Marine Laboratory)
Project Date: January 2020 - June 2021
Summary: This project is improving Mote Marine Lab's Beach Conditions Reporting System (BCRS) website and smartphone app. The BCRS is an important resource for the public, providing information on beach conditions and alerting the community on HAB risks. Improvements to the BCRS will include validation of citizen reports, integration and collaboration with outside data portals, and implementation of BloomZoom (see project summary below). The updates are expediting communication of the most up-to-date information about red tide blooms and giving citizens easier access to reporting.

Title: Evaluation of QUAT Efficacy for Florida Red Tide Mitigation
Principal Investigator: C. Heil (Mote Marine Laboratory)
Co-principal Investigators: E. Hall, A. Muni-Morgan, and E. Cuyler (Mote Marine Laboratory)
Project Date: January 2020 - June 2021
Summary: This project is examining the effectiveness of quaternary ammonium compounds (QUATs) at removing *K. brevis* cells and brevetoxins. QUATs are known to bond to negatively charged bacterial and algal cell walls, resulting in enzyme inactivation and disruption of membranes and cell processes. The charged cell walls of *K. brevis*, combined with their bacterial symbioses, suggest that this is a potentially effective treatment of *K. brevis* blooms without attendant toxicity issues. Two commonly used QUAT compounds are being absorbed on both concrete and fiberglass substrates and tested to evaluate *K. brevis* removal as well as impacts QUATs may have on water quality and cell physiology.

Title: Citizen Science Detection and Quantification of Florida Red Tides via Personal and Smartphone-enabled PCR Technology
Principal Investigator: C. Heil (Mote Marine Laboratory)

Project Date: January 2020 - June 2021
Co-principal Investigators: P. Countway, N. Record (Bigelow Lab for Ocean Sciences)
Summary: This project is focusing on the development and application of PCR technology to simultaneously identify and quantify *K. brevis* and *K. mikimotoi* in southwest Florida blooms and integrate it into Mote's Citizen Science Network. The project is comparing two quantitative polymerase chain reaction (qPCR) units for efficacy and user-friendliness and selects the better fit to be used for *Karenia* detection. Once the technology is tested and verified, citizen scientists will be trained to use the PCR unit to monitor HABs.

Title: Developing UAV-based Red Tide Detection System
Principal Investigator: V. Lovko (Mote Marine Laboratory)
Co-principal Investigators: S. Chakraborty (Mote Marine Laboratory)
Project Date: January 2020 - June 2021
Summary: This project is examining the use of unmanned aerial systems (UAS) as an alternative method for detection of red tide blooms compared to vessel and satellite sampling. Although aircraft and satellite remote sensing can potentially help determine bloom presence and extent, it is often limited by lack of ground truthing and poor temporal resolution. Airborne hyperspectral sensors can provide high spatio-temporal resolution mapping of HABs at local scales. This project is developing a hyperspectral database from UAS surveys to map red tide blooms using the Mote Airborne Red-tide Remote Sensing System (MARRSS).

Title: Testing the Efficacy of Products for Mitigating Harmful Effects of *Karenia brevis* Red Tide Events along the Florida Gulf Coast
Principal Investigators: R. Pierce (Mote Marine Laboratory)
Co-principal Investigator: C. Heil, E. Hall, V. Lovko, and J. Culter (Mote Marine Laboratory)
Project Date: January 2020 - June 2021
Summary: The ability to apply products to the natural environment requires studies to ensure efficacy in the field and that no further public health or ecological harm results from these mitigation applications. This project: 1) is testing potential mitigation products to determine optimal product dosing concentrations and protocol, 2) establishes product toxicity on other marine biota with standard EPA assays, 3) is determining production of toxic chemical degradation products impacts and half-lives in seawater, 4) is determining sub-lethal impacts of these compounds on *K. brevis* and non-targeted organisms, 5) is examining interactive compound effects on microbiota and nutrient cycling over short and long-term time scales (days to weeks) in pilot mesocosm experiments, and 6) verifies the efficacy and environmental compatibility of selected products with field applications during natural red tide events (when red tides occur during the study period).

Title: Pushing *Karenia* Over the Edge with Beer Derived Flavonoids
Principal Investigator: A. Place (University of Maryland)
Co-principal Investigators: T. Armstrong (University of Maryland Center for Environmental Science – Institute of Marine and Environmental Technology), V. Lovko, and R. Pierce (Mote Marine Laboratory)
Project Date: April 2020 - May 2021
Summary: This project is testing natural compounds from "brewer's spent grain" (BSG)—a readily available byproduct of beer breweries—for their potential to fight *K. brevis* and degrade its brevetoxins. Scientists know that a related product, barley straw, produces compounds that can fight certain algal blooms as the

straw decomposes over time. However, the slow release of compounds is not practical for *K. brevis* blooms that form in ocean waters offshore because it must be deployed well ahead of algal-bloom formation and remain near the bloom. Also, it is not clear that the barley straw would degrade or produce the same compounds in saltwater that it does in freshwater. In contrast, BSG has five times greater concentrations of certain barley compounds—phenolic acids and flavonoids—that can fight algae in the lab, and BSG is already releasing these compounds when it leaves the brewery, so project partners aim to assess its practical use for controlling *K. brevis* and its toxins.

Title: Fate and Effects of *Karenia brevis* Cells, Toxins, and Nutrients Following Clay Application for Bloom Control
Principal Investigator: D. Anderson (Woods Hole Oceanographic Institute)
Co-principal Investigators: R. Pierce, J. Culter, E. Hall, V. Lovko (Mote Marine Laboratory) and Dr. Kristy A. Lewis (University of Central Florida)
Project Date: May 2020 - June 2021
Summary: Laboratory studies suggest that kaolinite clay particles can "grab," sink, and destroy *K. brevis* algae, helping remove *K. brevis* cells and their toxins from water. Clays have been used to treat other algal blooms for more than 20 years in South Korea and China, often covering areas as large as 40 square miles, but further research is needed to transition clays for use in the U.S. This project is advancing ongoing research of kaolinite clay as an effective and ecologically sound method for mitigating and decreasing the impacts of Florida red tide. The team is using large experimental systems called mesocosms to further investigate how clay affects *K. brevis* and organisms from Gulf of Mexico environments. For example, when the clay pulls *K. brevis* to the bottom, do its toxins harm bottom-dwelling marine organisms more than they would without the clay? Does the clay capture or release nutrients? What are the best locations and procedures for applying clay? These and other questions must be addressed to apply clays to Florida red tide.

Title: Examining the Feasibility of Removing and Composting Fish Carcasses to Mitigate Red Tide
Principal Investigator: M. Parsons (Florida Gulf Coast University)
Co-principal Investigators: C. Heil (Mote Marine Laboratory)
Project Date: May 2020 - June 2021
Summary: Florida red tide can cause large-scale fish kills—a major impact to coastal ecosystems and communities' quality of life—and decomposing fish release nutrients that *K. brevis* can use, possibly causing a positive feedback loop that could worsen red tide. This process should be better quantified (represented in terms of numbers/quantities) to understand its significance. This project is quantifying the nutrient inputs to Florida red tide from fish kills in southwest Florida; is conducting a cost/benefit analysis of removing dead fish to help mitigate red tide; and is evaluating composting these fish (using a compost-accelerator compound) to produce fertilizer for local stakeholders.

Title: A Thin Shroud with Integrated Algaecide to Flocculate and Sink *Karenia brevis*
Principal Investigator: V. John (Tulane University)
Co-principal Investigators: T. Mclean (Tulane University)
Project Date: May 2020 - June 2021
Summary: Project scientists are testing an advanced technology designed to "smother" *K. brevis*, pull it to the bottom and treat it with algaecide in a targeted, controlled way. The technology is a super thin,

environmentally benign shroud called a "metal phenolic network" that will be combined with clay particles to weigh down the shroud will carry natural clay nanotubes with algaecide inside. This project focuses on testing the technology in the lab and in larger-scale "mesocosm" systems to understand its effectiveness, logistical and cost requirements, and potential side effects, such as release of toxins from dying *K. brevis* cells. If the project is successful, project leaders aim to transition to field experiments.

Title: Optimizing Production of a Dinoflagellate–specific Algicide for Control of *Karenia brevis*
Principal Investigator: K. Coyne (University of Delaware)
Co-principal Investigators: D. Wetzel and D. Lovko (Mote Marine Laboratory)
Project Date: June 2020 - July 2021
Summary: Researchers already know that certain bacteria naturally produce compounds that are "algicidal"—lethal to at least some species of algae. This project is focusing on optimizing production of algicide by certain bacteria for use on the Florida red tide alga, *Karenia brevis*, identifying which bacteria-produced compounds are the most algicidal to *K. brevis* and evaluating the potential risks of applying the algicide, starting experiments with *K. brevis* algae cultured in the lab and then validating those results with natural communities of microscopic algae.

Title: Automated *in situ* Advanced Sensing Technology Development for Red Tide Mitigation and Control (PHySS-C)
Principal Investigator: W. Haskell (Mote Marine Laboratory)
Co-principal Investigator: R. Pierce, G. Kirkpatrick, J. Hillier, K. Henderson, C. Caredio, and J. Turner (Mote Marine Laboratory)
Project Date: July 2020 - June 2021
Summary: This project is producing a new sensor technology to replace existing PHySS-2 sensors with next generation advanced technology multi-use, in situ sensors for red tide mitigation and control applications. The PHySS-C advanced sensing technology applications for red tide mitigation and control will include hyperspectral libraries of several phytoplankton species in addition to *K. brevis* to assess phytoplankton inter-species interactions related to red tide events. Sensors for water chemistry and physical parameters will allow for tracking of HAB dynamics. Data obtained from PHySS-C deployments will be utilized by collaborators for directing red tide bloom mitigation and control applications and to assess the efficacy of red tide mitigation techniques.

Title: BloomZoom: A Portable Phone-based Microscope for Quantitative Detection of *K. brevis* Through Citizen Science
Principal Investigator: V. Lovko (Mote Marine Laboratory)
Project Date: July 2020 - June 2021
Summary: This project is developing a portable microscope to detect and quantify *K. brevis* concentrations. The microscope will be adapted to fit any phone, tablet or other portable device so that citizens can use the device to collect samples and report data on *K. brevis* blooms. This technology enhances the accuracy of real-time information on red tide blooms and bloom forecasting.

Title: A Rapid Field Red Tide Toxin Biosensor for Commercially Important Shellfish and Seawater
Principal Investigator: D. Wetzel (Mote Marine Laboratory)

Co-principal Investigators: T. Sherwood and C. Miller (Mote Marine Laboratory)
Project Date: July 2020 - June 2021
Summary: This project is developing a rapid red tide toxin field biosensor for commercially important shellfish and seawater. This will reduce the time needed to quarantine shellfish farms due to red tide toxins, which is based on time-consuming laboratory analyses. The project also develops commercial application methods for depuration of red tide toxins from shellfish using a land-based recirculation system. These technologies will not only help the shellfish industry, they will also help reduce consumer risk and aid in red tide monitoring and research.

Title: Natural Compound Control and Mitigation for Red Tide
Principal Investigator: D. Wetzel (Mote Marine Laboratory)
Co-principal Investigators: T. Sherwood, A. Tarnecki, and C. Miller (Mote Marine Laboratory)
Project Date: July 2020 - June 2021
Summary: This project is examining the algicidal properties of naturally occurring bacteria, macroalgae, grasses, seawater and other materials against *K. brevis*. Algicides can play a role in prevention, termination and regulation of HABs with lower risk of harmful side effects than other control measures due to their natural occurrence in the environment. Algicidal compounds collected from the Gulf of Mexico are being identified, characterized and evaluated for effectiveness against *K. brevis* in mesocosm studies.

Title: Controlled Release Oxidants for Red Tide Treatment and Mitigation
Principal investigator: A. Carpenter (AxNano, LLC)
Co-principal investigators: C. Heil (Mote Marine Laboratory)
Project Date: November 2020 - December 2021
Summary: This project is utilizing AxNano RemRx™ controlled release oxidant technology, which combines an oxidizing substance with an environmentally-friendly polymer and releases it in tunable, controlled doses. Originally developed for treating contaminated groundwater, these technologies may prove effective at eliminating or preventing algal growth. The controlled release properties are hypothesized to reduce the stress on the ecosystem and the amount of toxin released by *K. brevis* decomposition.

Title: Microbe-Lift Mitigation 96 hour Testing with *Karenia brevis* (Red Tide)
Principal investigator: R. Elliott (Ecological Laboratories, Inc. – Enviro Water Quality Restoration, LLC)
Co-principal investigators: C. Heil (Mote Marine Laboratory)
Project Date: November 2020 - December 2021
Summary: The project is examining the efficacy of Microbe-Lift, a biotechnology created by Ecological Laboratories, Inc., that utilizes a series of cultured microbes to enhance and restore eutrophic aquatic ecosystems ranging from ponds, streams, rivers, and stormwater retention basins, and is commonly used in contained Koi and aquarium systems. This project will test the ability of Microbe-Lift to eliminate *K. brevis* cells and brevetoxins in laboratory experiments.

Title: Efficacy of EVIE robot against *K. brevis*
Principal investigator: A. Lyles (Solaris Cybernetics)
Co-principal investigator: R. Pierce (Mote Marine Laboratory) and R. Behrens (Solaris Cybernetics)
Project Date: November 2020 - December 2021

Summary: A robotic vessel, nicknamed EVIE, is being tested in a mesocosm setting to determine its ability to a) find Florida red tide cells via a finely-tuned reflected-light sensor, and b) subsequently harvest cells via a nozzle, convert them to harmless biofuels, and store the product in the robot's holding tank.

Title: In-situ Mitigation of Florida Red Tide via Activated Carbon
Principal investigator: R. Rodrguez (Carbonxt)
Co-principal investigator: V. Lovko (Mote Marine Laboratory)
Project Date: November 2020 - December 2021
Summary: This project is developing and investigating activated carbon products as both an adsorbent for brevetoxins and as an inhibitor for the spread of Florida red tide cells, *K. brevis*. Activated carbon is a highly versatile and widely-used product for filtering water and air. Activated carbon is well-suited for testing its application in controlling algae blooms due to its high affinity for contaminants, such as brevetoxins, and its ability to serve as a great substrate for impregnating with substances that can kill *K. brevis*.

Title: Isolation of Natural Algicidal Bacteria Associated with Harmful Algal Blooms to Develop a Mitigation Strategy for Florida Red Tide
Principal investigator: G. Phillippidis (University of South Florida, Patel College of Global Sustainability)
Co-principal investigator: V. Lovko (Mote Marine Laboratory)
Project Date: December 2020 - January 2021
Summary: This project is assessing the microbial community associated with *K. brevis* to identify natural bacteria that possess algicidal properties and can help mitigate blooms of Florida red tide.

Title: A Preliminary Study to Assess the Feasibility of a Nanotechnology Approach to the Removal of *Karenia brevis* cells and Brevetoxin from Estuarine and Marine Waters
Principal investigator: J. Lead (University of South Carolina SmartState Center for Environmental Nanoscience and Risk)
Co-principal investigator: C. Heil (Mote Marine Laboratory)
Project Date: January 2021 - February 2022
Summary: This project is using a nanotechnological approach to separate *K. brevis* cells and their toxins from seawater. Using an established strategy for oil and metal remediation, magnetic, polymer-coated nanoparticles will be tested to see if they can effectively attract both brevetoxins and *K. brevis* cells and remove them from the water.

Title: A chemical-free Red Tide Mitigation Technology Utilizing UVC LEDs
Principal investigator: N. Williams (nTecSolutions LTD)
Co-principal investigators: K. Rein (Florida International University) and R. Pierce (Mote Marine Laboratory)
Project Date: January 2021 - February 2022
Summary: This project is examining the development of a field device that utilizes ultraviolet wavelengths from 260 nanometers to 280 nanometers (UVC) to prevent or mitigate algae blooms in small to medium scale aquatic ecosystems. UVC has been used in many industries for disinfection purposes, and UV lamps are frequently used in aquarium systems and small ponds to prevent the growth of algae. This project is investigating using solar panels to power a device that is triggered by specific levels of *K. brevis*, and will use UVC from light-emitting diodes to maintain non-bloom levels of cells of *K. brevis*, with the goal of stopping a bloom before it develops or to halt an ongoing bloom.