Florida Red Tide Mitigation and Technology Development Initiative

Technical Advisory Council Public Meeting

April 3, 2020

Florida Red Tide Mitigation and Technology Development Initiative

Technical Advisory Council

Dr. Michael P. Crosby, Chair – Mote President & CEO

Dr. James Powell – House Speaker Appt

Dr. James Sullivan – Senate President Appt

Dr. Katherine Hubbard – FWC Appt

David Whiting – DEP Appt

Governor Appointee Pending

Meeting Agenda

- Webinar and Phone Technical Checks
- Ensure Council Members are Present
- Meeting Facilitation Plan
  - Time for Council Questions and Comments after each section
  - TAC 4* to unmute or remute
- Review of 1st Council meeting, January 17, 2020
  - Minutes available at Mote.org
- Year 1 Status:
  - Mesocosm and Culture Lab Infrastructure
  - Mote Projects
  - Partner Led Projects
- Year 2 Timeline Plans
- Public Comments – *please indicate in the comment box if you would like to make a comment, please limit remarks to 3min or less*
- Closing – Any Final Council Member Remarks

January 17 TAC Meeting

- Overview of the Red Tide Initiative
- Role of the TAC and Quorum
- Sunshine and Public Record Laws
- Meeting Minutes
- Red Tide Initiative Website on Mote.org
- Florida Red Tide Background
- Statutory Reporting Requirements
- FWC Contract and Reporting Requirements
- Initiative Outreach
- Summary of Year 1 Activities

Since 1st Meeting, We're On Course and On Schedule

Questions or Comments from the TAC?

(4 to unmute)*

Florida Red Tide Mitigation and Technology Development Initiative

Mote Marine Laboratory Aquaculture Research Park Mesocosm and Culture Lab Infrastructure

Experimental Mesocosm Facility

Motivation

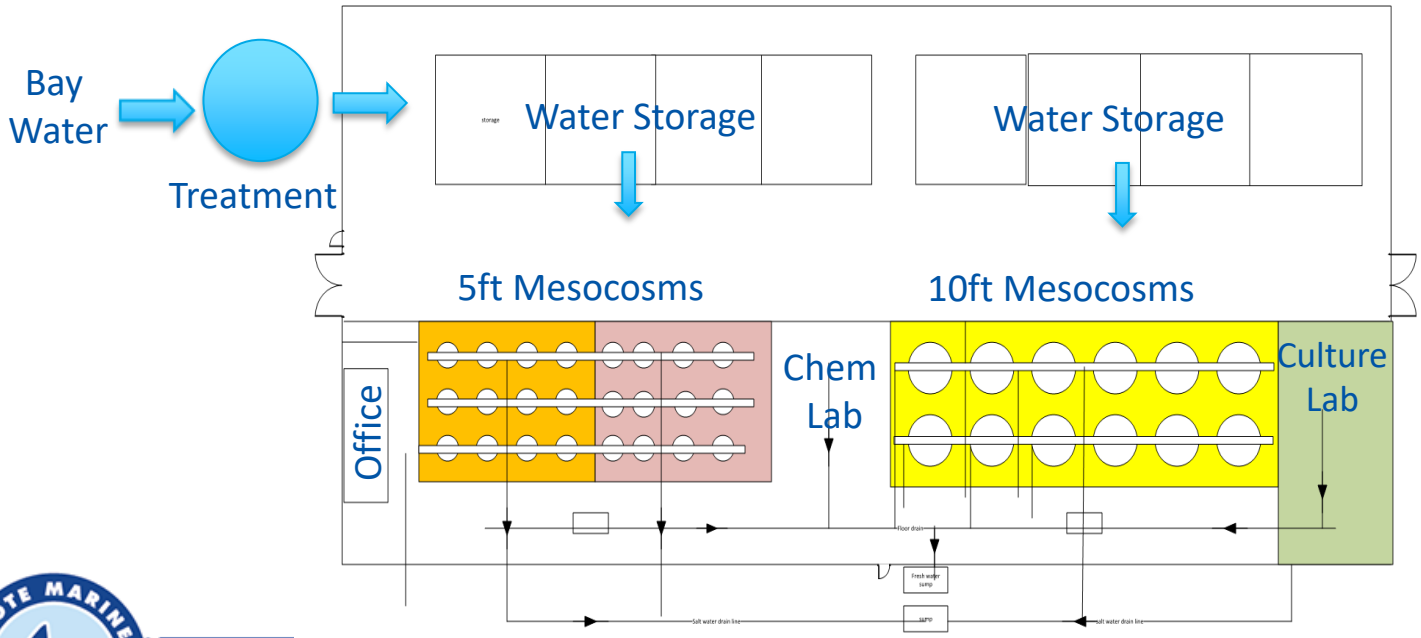
- To provide multi-scale, multi-user red tide research infrastructure for Initiative scientists

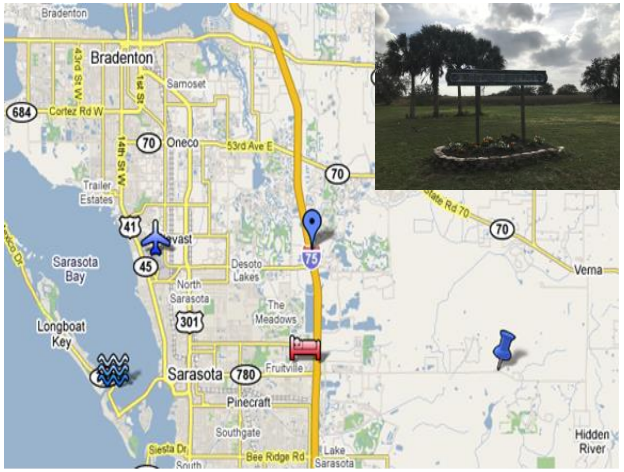
Goals

- Used by visiting Initiative scientists, graduate students, and educational groups

Outcomes

- Dedicated red tide mitigation mesocosm facility will allow more ecosystem-based testing of mitigation compounds in a controlled setting to prepare for field implementation

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Verna
North Sarasota
The Meadows
Longboat Key
Sarasota
Fruitville
Pinecraft
Southgate
Siesta Dr
Bee Ridge Rd
Lake Sarasota
Hidden River

Phytoplankton Culture Facility

Motivation

- To support the Initiative with *Karenia brevis* culture

Goals

- Meet the demands of the mitigation research with **consistent and reliable production of large volumes of *K. brevis***
- Expand collection of *K. brevis* species (growing and maintaining several different strains)

Outcomes

- Leverage Mote's strong foundation of ecology, advanced biology and physiology to collaborate at state, national, and international **levels** and improve scientific productivity - i.e. support this Initiative with culture and Red Tide expertise

Update:

- Construction underway, walls going up, layout being finalized
- Equipment ordered

Questions or Comments from the TAC?

(4 to unmute)*

Florida Red Tide Mitigation and Technology Development Initiative

Mote Led
Year 1 Projects

Mote Led Project Updates

- Technology Development in Support of Mitigation
  - Programmable Hyperspectral Seawater Scanner (PHySS)
  - UAV (Unmanned Aerial Vehicle, Drone) - based Detection System
  - Beach Conditions Reporting Systems (BCRS)
  - Quantitative Polymerase Chain Reaction (qPCR)
- Mitigation Projects
  - Compounds (Natural, Clay, Chemicals)
  - Laboratory and Mesocosm

- *Mote scientist collaboration with Partner Led Projects*
- *Coordination with other funding sources (and thanks for our NOAA and FWC partners joining the call today)*

PHySS(2.0) - Programmable Hyperspectral Seawater Scanner

Motivation:

- Develop an instrument to aid in the mitigation of red tide and provide early detection and warning
- Developed at Mote; Similarity Index; fully programmable data acquisition with web-based data analysis tool

Goals:

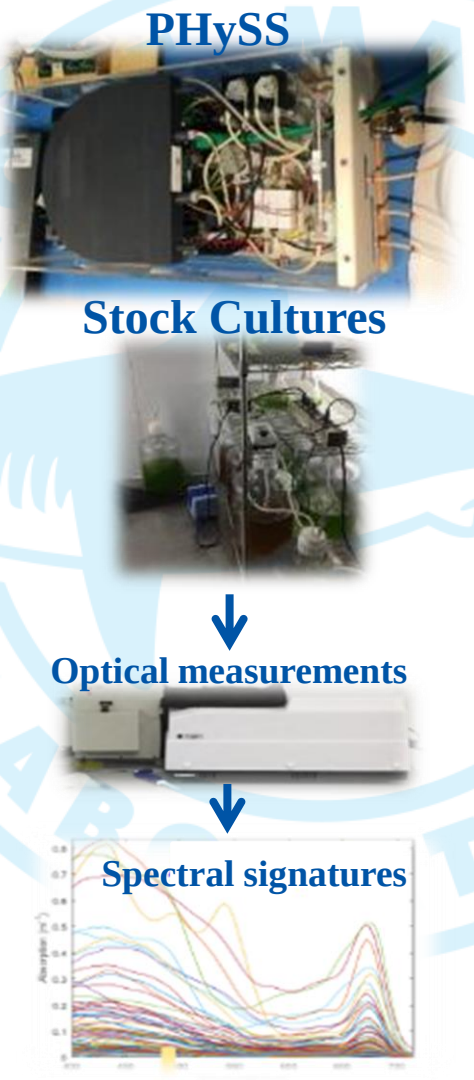
- Develop a spectral library of different phytoplankton groups with variable morphologies and physiological states, optical signatures will be obtained for a range of cell densities
- Improve sensitivity, identify multiple phytoplankton groups
- Achieve concurrence with direct and remote observations of the SI estimates across different biological and physical regimes

Outcome:

- Form observatory providing continuous high frequency data
- Data will be made publicly available in web based platform

Update:

- **Task1:** Parts for new PHySS 2.0 ordered, assembly will start soon.
- **Task2:** Starting cultures (first set) received, phytoplankton will be grown in lab and will start creating the hyperspectral library.
- **Task3:** Low power alternative processor; installed and being tested.



UAV-based Red Tide Detection System

Motivation:

- Patchy nature of red tide makes mitigation technology challenging
- Airborne hyperspectral sensors could allow the mapping of HABs with a high spatio-temporal resolution at local (drone) and regional (satellite) scales.

Goals:

- Conduct shore-based flights in local waters
- Collect hyperspectral data, develop data processing scheme, instrument calibration and deliver proof-of-concept
- Quality control check of algorithm performance
- Implementation of new approaches for algorithm development

Outcomes:

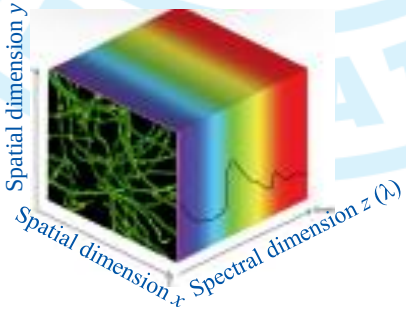
- Develop an application tool to assist in management of events that may involve significant risk to the public
- Decrease costs of detection, improve mitigation application

Updates:

- Ordered Equipment – laptop and a downwelling irradiance sensor
- Evaluation of data collected

Imagery of red tide collected from drone

Hyperspectral data cube



Advance Red Tide Reporting Technology

Motivation:

- Alert the Public of Red Tide and its Effects
- Red Tide reporting in hands of fisherman

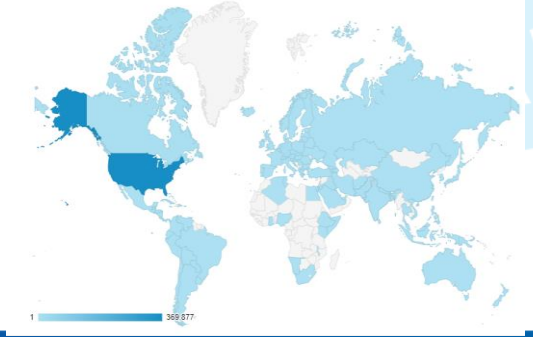
Goals:

- Update/combine the Beach Condition Reporting System with the Citizen Science is Cool App
- Enhance validation components
- Bloom Zoom for cell detection, App for Chl-a

Outcomes:

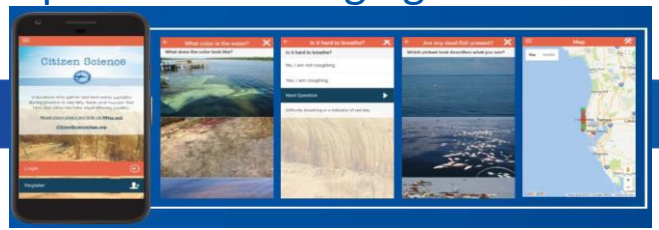
- Information disseminated to BCRS/App, GCOOS, SECOORA and NOAA
- Reporting to/by anyone with a Cell Phone, anywhere.

Since October 15, 2017
Unique Users: 1.5Million
Page Views: >4.5Million



Update:

- Contract completed
- Contractor began redevelopment and merging BCRS and CSIC



Acceleration of user-friendly, smart phone integrated qPCR technology development and Citizen Science integration for *K. brevis* mitigation testing

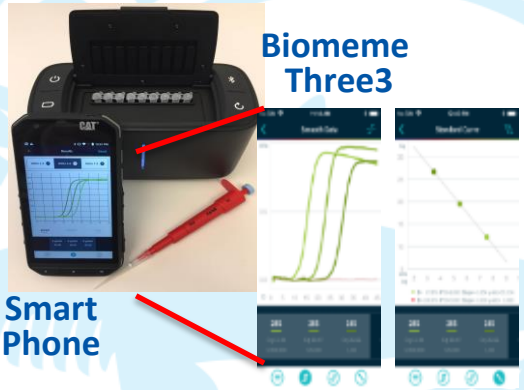
Drs. Cynthia Heil & Tracy Fanara

Motivation:

Meet the ongoing, well-defined, need for new public-friendly, automated, web-interfaced detection methodologies that can provide accurate and timely cell monitoring data.

Overall Goal:

Accelerate the development and validation of a hand-held, qPCR based *K. brevis* and *K. mikimotoi* detector (Biomeme Three3) and develop protocols for integration into Citizen Science program.



- 9 samples per run
- 3 qPCR assays at once
- Stable reagents
- Smartphone interface
- Cloud-based data storage

Updates (and Alternatives):

- We have ramped up *K. brevis* culturing & are obtaining an eastern Gulf *K. mikimotoi* clone (Venice) from the UNCW Algal Resources Collection
- A PO in place for purchase of a Biomeme is delayed as the units are being used for COVID-19 tests. We are borrowing Bigelow's unit & existing supplies for the research
- We have modified our subcontract with Bigelow collaborators to include remote development and Instruction as much as possible.
  - We still hope to have Collaborators (Drs Countway & Record) visit Mote in mid/late May

Mitigation Products & Processes
Introduction

Motivation:

To build on advancements made through the on-going FWC-Mote Cooperative Red Tide Research Program to develop science–based response strategies to reduce the intensity of red tide events and mitigate impacts on coastal ecosystems, Florida's economy, and public health.

Overall Goal:

To develop, test and implement the most effective and ecologically sound products and technologies for mitigation and/or control of adverse impacts of Florida Red Tides, in collaboration with experts from multiple external research institutions.

Outcome:

Implement a tiered approach to investigate products in a science-based protocol to identify the most effective and ecologically sound products and technologies for mitigation and/or control of adverse impacts of Florida Red Tides.

- Tier 1. Lab-scale tests to determine the effective methodology for eliminating *K. brevis* cells and toxins.
- Tier 2. Mesocosm-scale (larger volume, multiple organisms) to assess impacts of non-targeted marine organisms and water quality
- Tier 3. Open Field applications: Test the most appropriate method(s) under natural field conditions (timing depends on outcome of previous tests, permission for field application and red tide events).

Tier-1 Lab studies

Tier-2 Mesocosm- scale

Tier-3
Clay field application in canal

Mitigation Products & Processes
Applications

Mitigation Products Tested for Year-1;

Task1:Natural Products:

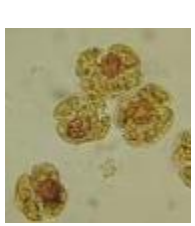
- **Ulva species; Macro Algal Allelopathy;**
  - establishing growth conditions & nutrient impacts

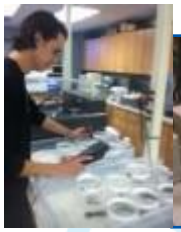
2. Chemical Products:

- **Curcumin: Polyphenol antibiotic properties**
  - after 48 hrs, loss 96% of cells; 63% of toxins

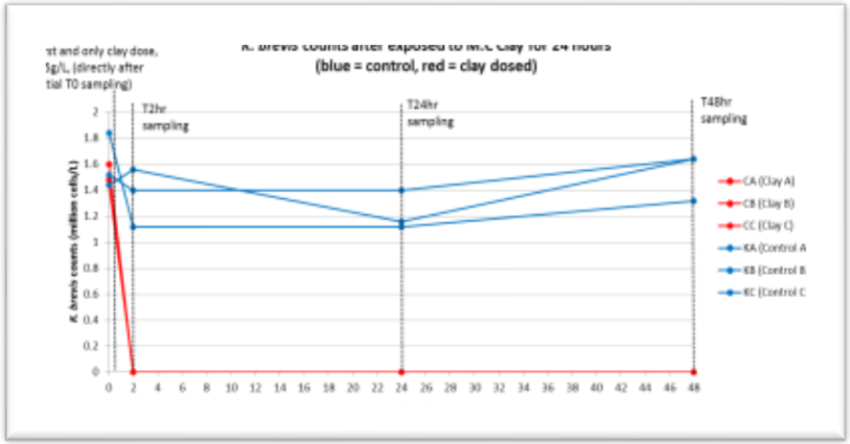
3. Physical Processes

- **Clay flocculation; 5g clay/M^2 water surface**
  - dose 1.5 x10^6 cells/L
  - cells 100% loss 2 hrs; Toxins PbTx-2; 80% loss

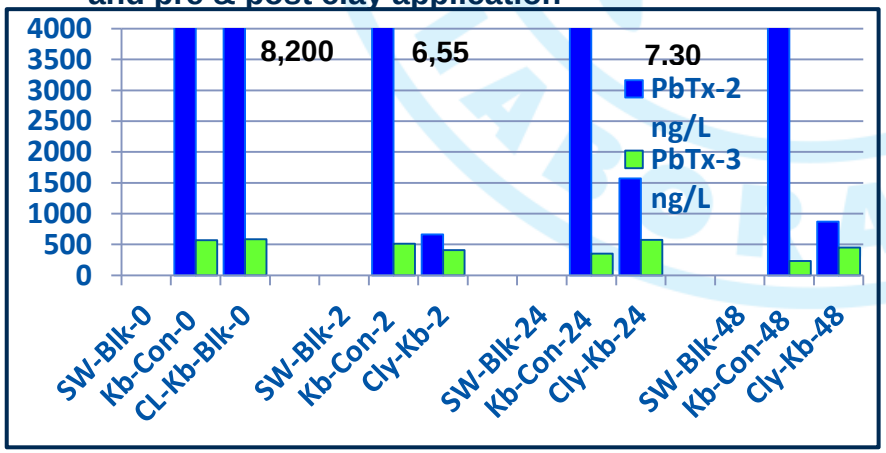




K. brevis Water Quality Nutrients Toxins



Brevetoxins ng/L in Sea Water, *K. brevis* culture, and pre & post clay application



Questions or Comments from the TAC?

(4 to unmute)*

Florida Red Tide Mitigation and Technology Development Initiative

Partner Led
Year 1 Projects

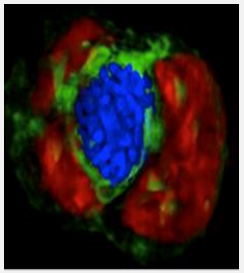
Red Tide Initiative - Partner Led Proposals

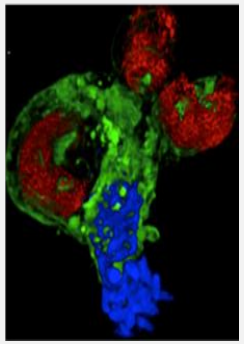
- Open to any/all interested parties
- $1 Million in funding for partner led projects
  - 5 Selected to present overviews to TAC
  - Support not to exceed 1 year
    - may request longer in second year RFP
- Proposal guidelines and proposal submission:
  - Mote.org
  - Announced November 7th at US HAB Symposium
  - Webinar on RFP and to answer any questions
  - Due January 31st to proposals@redtidemtdi.org
- Use of Mote facilities/infrastructure was encouraged
- Partner Led Proposal Review Process:
  - Diverse set of red tide PhD level expertise from NOAA, EPA, FWC, Universities, Estuary Programs, and Mote
  - Each scientist reviewed 3-5 proposals using provided questionnaire
  - Additional Non-Conflicted Mote Scientist Review
    - » Mr. Claridge organized and provided all reviews together for Dr. Crosby's decision

Red Tide Initiative - Partner Led Projects

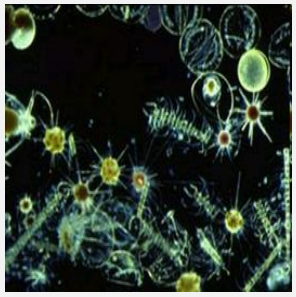
1. Dr. Kathryn J. Coyne, University of Delaware: *Optimizing production of a dinoflagellate–specific algicide for control of Karenia brevis*
2. Dr. Allen Place (Taylor Armstrong presenting), University of Maryland: *Pushing Karenia Over the Edge with Beer Derived Flavonoids*
3. Dr. Vijay John, Tulane University: *A Thin Shroud with Integrated Algaecide to Flocculate and Sink Karenia brevis*
4. Dr. Don Anderson, Woods Hole Oceanographic Institute: *Fate and Effects of Karenia brevis Cells, Toxins, and Nutrients Following Clay Application for Bloom Control*
5. Dr. Michael Parsons, Florida Gulf Coast University: *Examining the Feasibility of Removing and Composting Fish Carcasses to Mitigate Red Tide*

Optimizing production of a bacterial algicide for control of *K brevis*

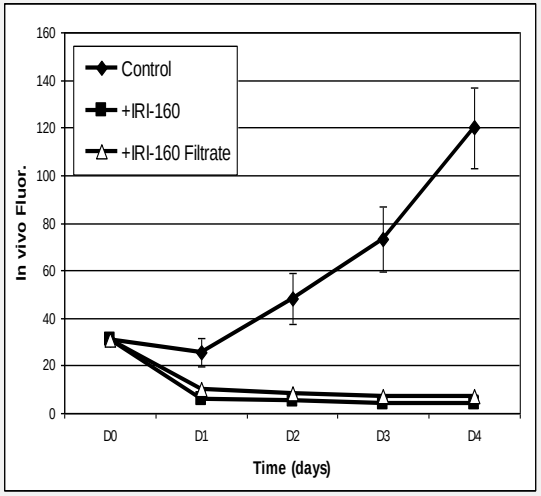




Lead: Kathryn J. Coyne, Associate Professor
University of Delaware
Co-PIs: Dana Wetzel and Vincent Lovko
Mote Marine Laboratory



Contact with bacteria is not necessary for algicidal activity



Bacteria-free filtrate is as effective as adding bacteria

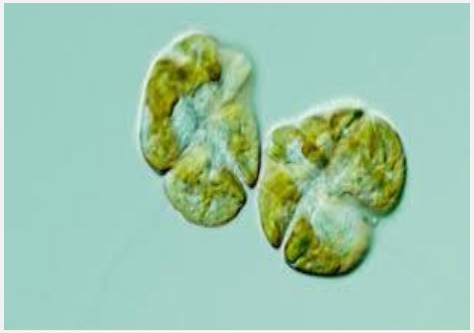
Pokrzywinski et al. 2012

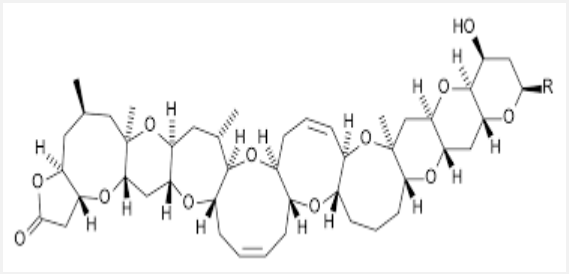
Algicidal compounds in the filtrate include a number of amines

- These compounds act synergistically to induce cell death in dinoflagellates
- Sensitivity to amines differs depending on species of dinoflagellate

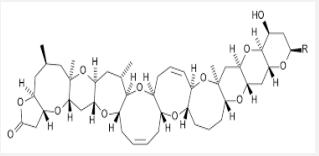
Overall Goals:

1. Optimize production of algicide by the bacteria for use on *Karenia brevis*
2. Identify algicidal compounds (amines) that have the greatest impact on *Karenia brevis*
3. Evaluate risks of algicide application: Does it increase the release of brevetoxin?
4. Validate laboratory culture experiments with natural communities of phytoplankton





Detailed objectives for this project:



- Optimize production of the algicide for controlling *Karenia brevis*
  - Bacteria will be cultured with different nutrients and under different environmental conditions
  - Algicide will be tested on *Karenia* to identify optimal growth conditions
- Measure concentrations of amines in optimized algicide
- Compare algicidal activity of bacterial algicide with commercially available amines at same concentrations
  - Amines will be tested alone or in combination to identify algicidal components that are effective for controlling *Karenia brevis*
- Measure brevetoxin concentrations in cultures exposed to the algicide
  - Risk assessment
- Evaluate sensitivity of different strains of *Karenia brevis* to the algicide
- Conduct microcosm experiments to confirm algicidal activity of commercially available amines

Roles of each team member:

- Kathryn Coyne (Lead PI, University of Delaware) and postdoctoral researcher (based at UD)
  - Coordinate activities among team members
  - Optimize algicide production by bacteria
  - Compare algicidal activity of bacteria-produced algicide to commercially available amines
  - Conduct microcosm experiments
- Dana Wetzel (Mote Marine Laboratory)
  - Identify and quantify algicidal components during optimization
  - Brevetoxin analysis for culture and microcosm experiments
- Vincent Lovko (Mote Marine Laboratory)
  - Provide cultures for laboratory experiments
  - Conduct strain sensitivity assays
  - Participate in microcosm experiments

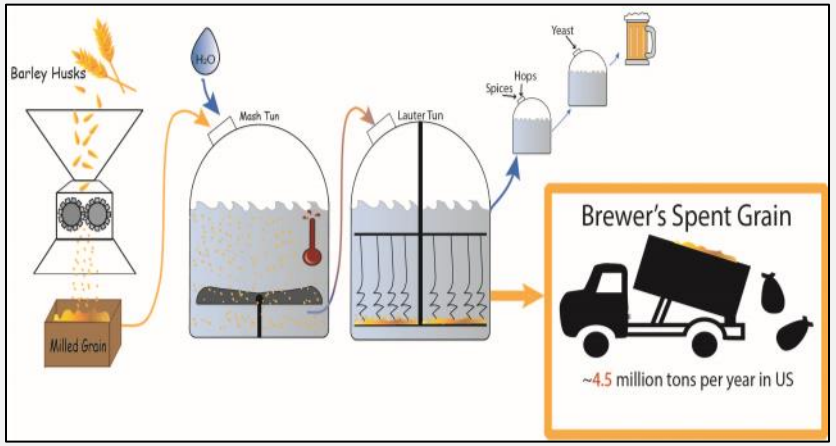
Pushing Karenia Over the Edge with Beer Derived Flavonoids



Dr. Allen Place and graduate student **Taylor Armstrong**
University of Maryland Center for Environmental Science-IMET



Dr. Vincent Lovko and **Dr. Richard Pierce**
Mote Marine Laboratory



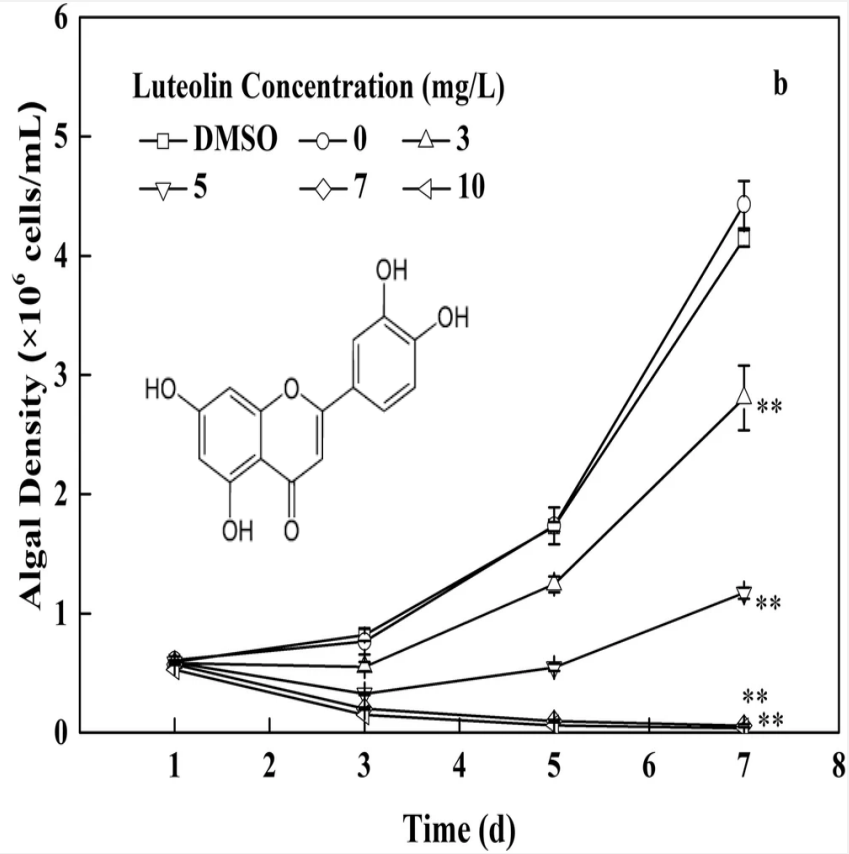
Barley straw:

- Used as mitigation technique for cyanobacteria
- Effective against toxic dinoflagellates in lab experiments
- BUT, dispersal can be time consuming, labor intensive, and its effectiveness is dependent on deploying bales ~12 weeks prior to the bloom formation

Beer Waste:

- Readily available at little to no cost
- 5x concentration of phenolic acids/flavonoids

Luteolin: Positive Control



Growth curve of *M.aeruginosa* exposed to Luteolin (Chen et al. 2019)

Research Objectives

Impact on cell growth and brevetoxins

1. Examine the effect of luteolin & BSG extracts on multiple strains of *K. brevis* growth. (Place & Lovko)
2. Identify the dose-response of luteolin & BSG needed to achieve 95% cell death (Place & Lovko)
3. Measure brevetoxin degradation rate with luteolin & BSG (A side goal is to examine the effectiveness of using PTFE syring filters as a replacement for C18-glass fiber filters for sampling of brevetoxins) (Place & Pierce)

Sublethal effects on cells

4. Elucidate the inhibitory mechanisms of luteolin & BSG on *K. brevis* at sub-lethal levels (Place, Lovko &Pierce)
5. Analyze impact of luteolin & BSG on photosythnetic function of *K. brevis* using PAM fluorometry. (Place & Lovko)

Identify algicide(s)

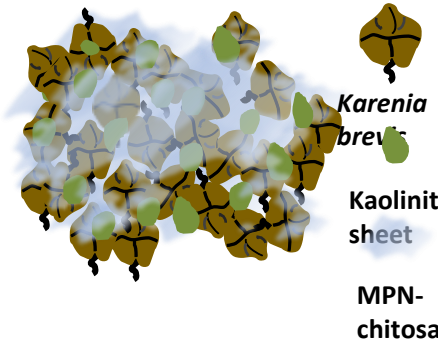
Test on natural bloom

6. Separate algicidal fractions of BSG (late effort) (Place)
7. Test whole BSG and BSG extract on natural *K. brevis* bloom using mesocosms (Lovko)

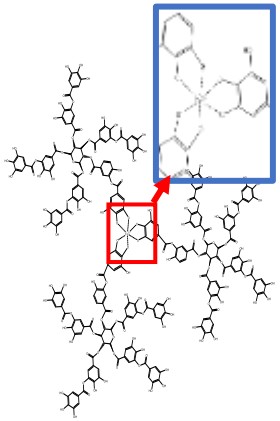
A Thin Shroud with Integrated Algaecide to Flocculate and Sink *Karenia brevis*

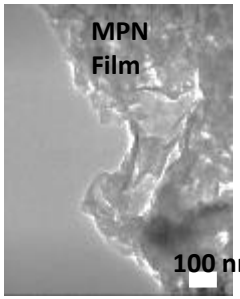
Vijay John, Tim Mclean – Tulane University

Our Findings

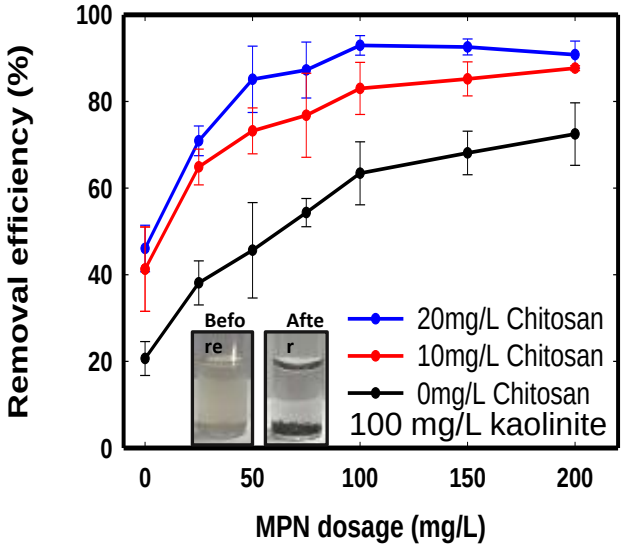


1. The concept of the shroud

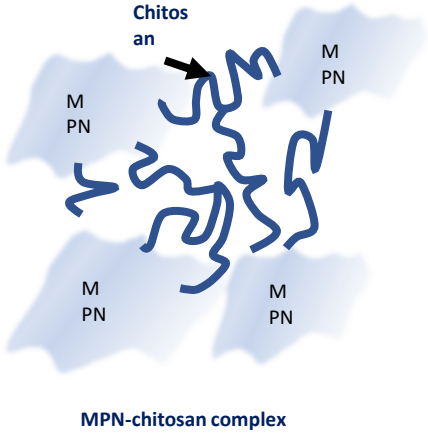




2. Metal Phenolic Networks (MPNs) form the shroud

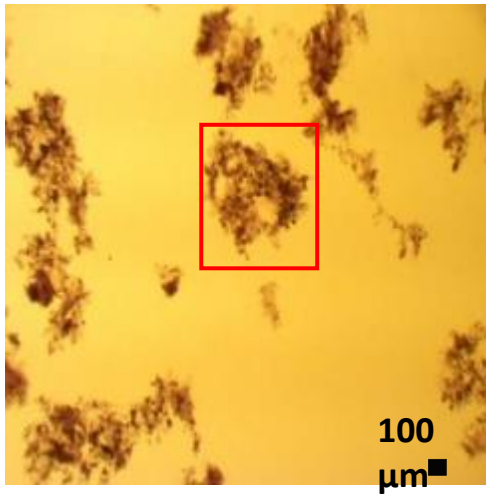


3. High sinking efficiencies with engineered system

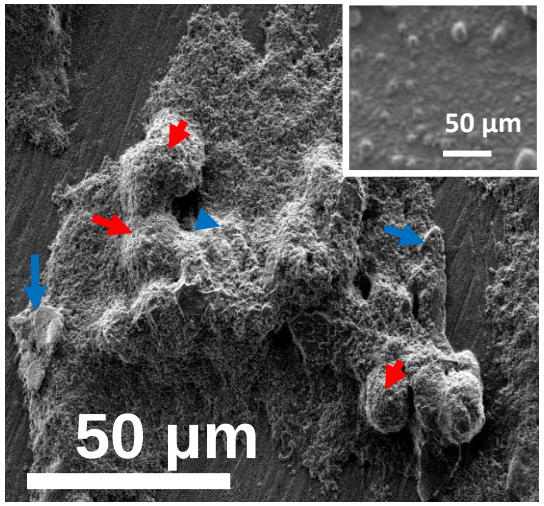


MPN-chitosan complex

4. Chitosan extends the shroud



5. Optical micrographs

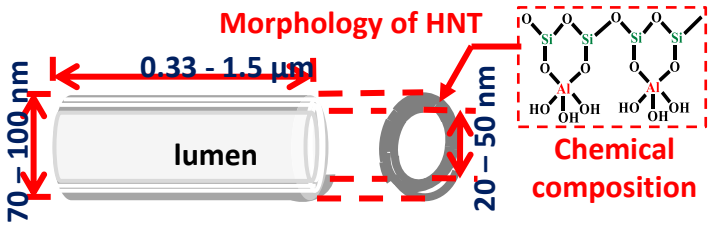


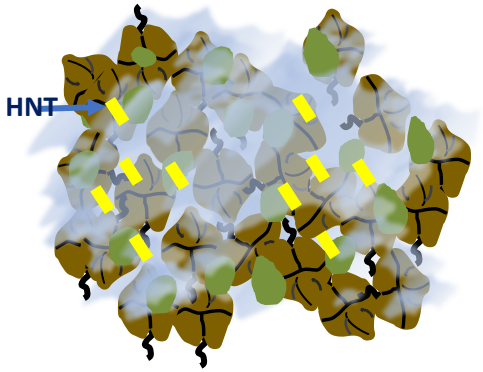
6. Cryo SEMs.

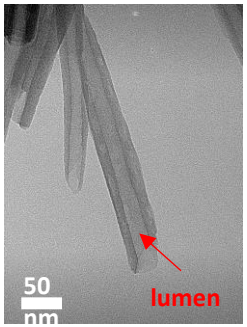
A Thin Shroud with Integrated Algaecide to Flocculate and Sink *Karenia brevis*

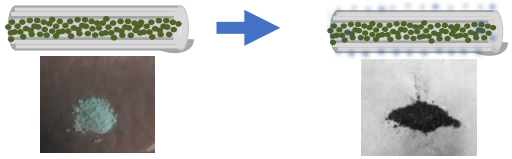
Vijay John, Tim Mclean – Tulane University

Our Proposed Work









Cu(II)-loaded HNTs

Stoppered-Cu(II)-loaded HNTs

1. Halloysite nanotubes (HNT) as targeted delivery systems

HNTs are natural clays with a scroll like structure.
The lumen can be used to encapsulate materials.
Our objective is to encapsulate algaecide and integrate this into the shroud for targeted delivery.

2. System optimization for sinking efficiency and algaecide delivery.

3. Collaboration with Mote and FWRI

a. Translation to mesocosms (raceway tables and tanks).
b. Understanding toxin release
c. Implications to off-target organism toxicity

4. Other considerations

a. Logistics
b. Cost

We will work with intensity to transition to field tests in a year.

Fate and effects of *Karenia brevis* cells, toxins, and nutrients following clay application for bloom control





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Mote Marine Laboratory

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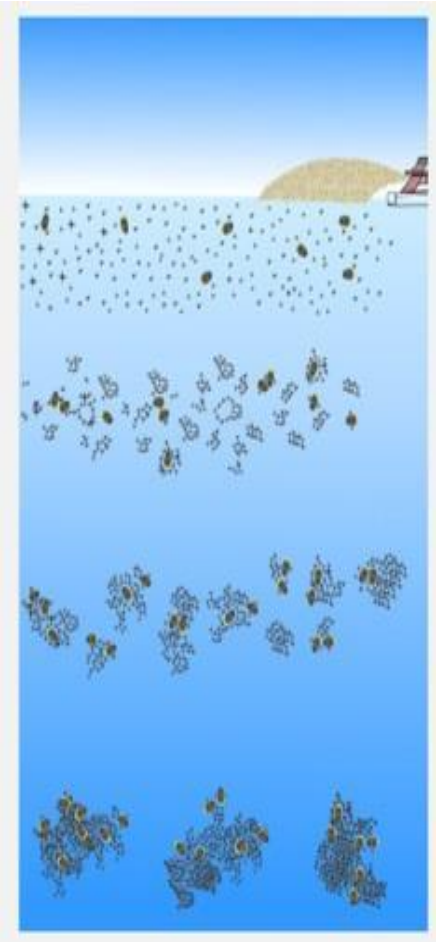
The approach



- The most globally advanced and widely used red tide control strategy; used in China and South Korea for over 20 years for large-scale bloom control.
- Not yet accepted for use in the US.
- Most assessments not conducted with organisms that produce neurotoxins (i.e. brevetoxin).
- The few that have used *Karenia* have been short-duration experiments in flasks and thus have not addressed the dynamics of cells, toxins, nutrients, and the clay floc, including impacts on complex natural communities that live in and on bottom sediments.
- **Critical studies of this type are the subject of this proposal.**
- Work will parallel proposed pilot-scale studies in canals and bays that address different questions and scales

The approach will rely heavily on Mote infrastructure developments – mass-culturing facilities, tall mesocosm tanks in incubators, large outdoor, flow-through tanks and limnocorrals to be used with natural sediments and communities

OBJECTIVES:

1. *Determine long-term fate of Karenia cells, toxins, metals, and nutrients removed from surface waters after clay application.*
2. *Assess benthic impacts resulting from clay flocculation of Karenia.*
3. *Communicate results of the study to managers and stakeholders.*



GOALS TO BE ACHIEVED:

- Learn whether the benefit from the suppressed bloom is or is not counterbalanced to a significant extent by high toxicity and significant negative impacts in the benthos compared to the red tide alone.
- Learn whether the impacts on nutrients from clay flocculation is positive or negative (i.e., long-term removal through adsorption, versus release and possible stimulation of future algal growth).
- Learn whether there is release of aluminum from the PAC polymer through time.
- Document longer-term impacts of deposited floc on the benthos and chemistry.
- Provide guidance on the proper locations and procedure for clay application
- Move this promising technology forward towards large-scale application in Florida

Parsons & Heil: Examining the Feasibility of Removing Fish Carcasses to Mitigate Red Tide

- *Karenia brevis* produces brevetoxins, which can kill fish when cell concentrations are high enough
- The dead fish decompose, releasing nutrients, further fueling the bloom
- The growing bloom kills more fish, more nutrients are released, etc.
- Is fish removal and composting a viable option to mitigate *Karenia brevis* blooms?

Florida Gulf Coast University

Mote Marine Laboratory

Proposed Study:

- Better quantify the nutrient inputs to red tide from fish kills in southwest Florida;
- Conduct a cost/benefit analysis of fish removal as a mitigation tool;
- Evaluate composting and use of a compost accelerator compound to repurpose the dead fish as fertilizer for local stakeholder use.

Questions or Comments from the TAC?

(4 to unmute)*

Red Tide Initiative Year 2

- Continue Admin, Contracting, Invoicing, etc
- Continue Website updates and Outreach
- Develop Year 2 budget
- Mote preparing concepts in April 2020
- Request For Proposals May 1 – June 30
- Operation and Maintenance of infrastructure
- TAC Meeting in September after proposal review
- Statutory Required Report (due Jan 2021)
  - Progress and Strategic Steps toward “Red Tide Tool Box”

Questions or Comments from the TAC?

(4 to unmute)*

Public Comments and/or Submitting Written Comments for the Minutes

Kevin Claridge
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Closing
Questions or Comments from the TAC?

(4* to unmute)

Thank You!

Any Questions/Comments:

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