

Florida Red Tide Mitigation and Technology Development Initiative

Technology Advisory Council Meeting

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November 17, 2022



TAC Meeting Agenda

- TAC Roll Call and FAR Public Notice
- Red Tide Initiative Overview
- Facility Updates
- Overview of Progress
- Initiative Reporting
- Requests For Proposals and Projects
- Promising Mitigation Tools
- Next Steps
- Public Comments
- TAC Comments and Recommendations



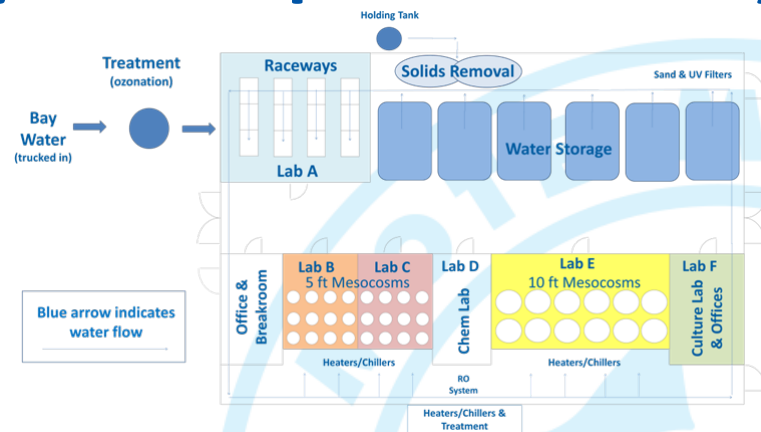
Red Tide Initiative Overview

- Signed by Governor DeSantis in June 2019
 - 379.2273 Florida Statutes
 - Mote partnership with Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute
- \$18 million over 6 years (\$3 million per year)
 - Sunsets March 2025
- Numerous Reporting requirements
- Legislative intent:
 - develop **mitigation** technologies and approaches to address the impacts of red tide on coastal environments and communities in Florida
- General Structure:
 - Lab space, *Karenia brevis* culture, raceways and mesocosms for:
 - Projects leading to red tide mitigation tools
- **Regulatory Oversight and Commercialization**



Mitigation and Technology Development Facility

- Mote Aquaculture Research Park
- 150K gallons treated and recirculated seawater
- Tiered safe setting research through lab-based, large-scale 5ft and 10ft mesocosms, and raceways
- Large volumes of *K. brevis*
- Ecosystem-based testing of mitigation compounds in a controlled setting to prepare for field implementation
- Enhanced air treatment, PPE provided, and air testing
- Do no additional health or environmental harm
- No charge for facility use, culture, and assistance as part of Initiative
- **Busy Year with Facility Reservations**



Research Mesocosms



Research Raceways



Red Tide Culture



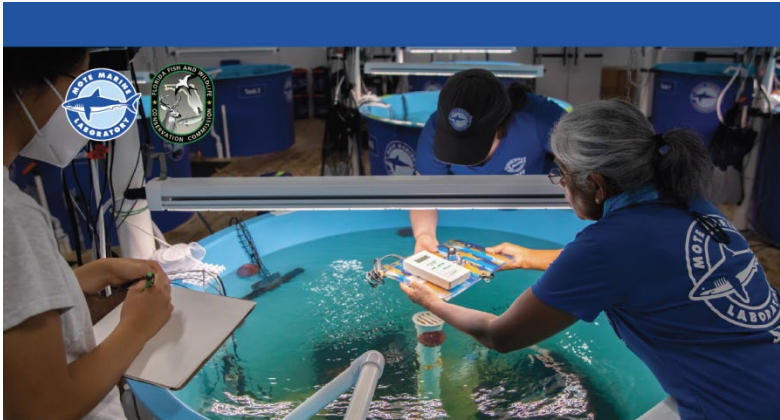
Facility Grand Opening



Partnership Signage



Red Tide Initiative Progress



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

ACCOMPLISHMENTS AND PRIORITIES REPORT

JANUARY 2022

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 1700's and their likely impacts date back to 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.

- ✓ 200+ Potential Mitigation Compounds Examined for Tiered Testing
- ✓ 4 RFP's and 4 Webinars
- ✓ 5 TAC Meetings
- ✓ 100+ Proposals Reviewed
- ✓ 25+ Projects Underway
- ✓ 20+ Funded External Partners
- ✓ Mitigation Tools to Fast Track
- ✓ Research Facility Constructed
- ✓ Private/Federal Funding Leveraged
- ✓ Public Website
- ✓ Science to Commercialization Workshop
- ✓ Report to Governor, Legislature, & Agencies on Accomplishments & Priorities
- ✓ Approximately a dozen promising tools and technologies for commercialization

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Available on Mote's Red Tide Initiative Website



MOTE.ORG

Initiative Reporting

- **379.2273(2)(d) Florida Statutes:**

Beginning January 15, 2021, and each January 15 thereafter until its expiration, 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.

- **FWC-FWRI Contract Reports**

Technical and Financial

Regular partnership interactions

- **Project Interim and Final Reports**

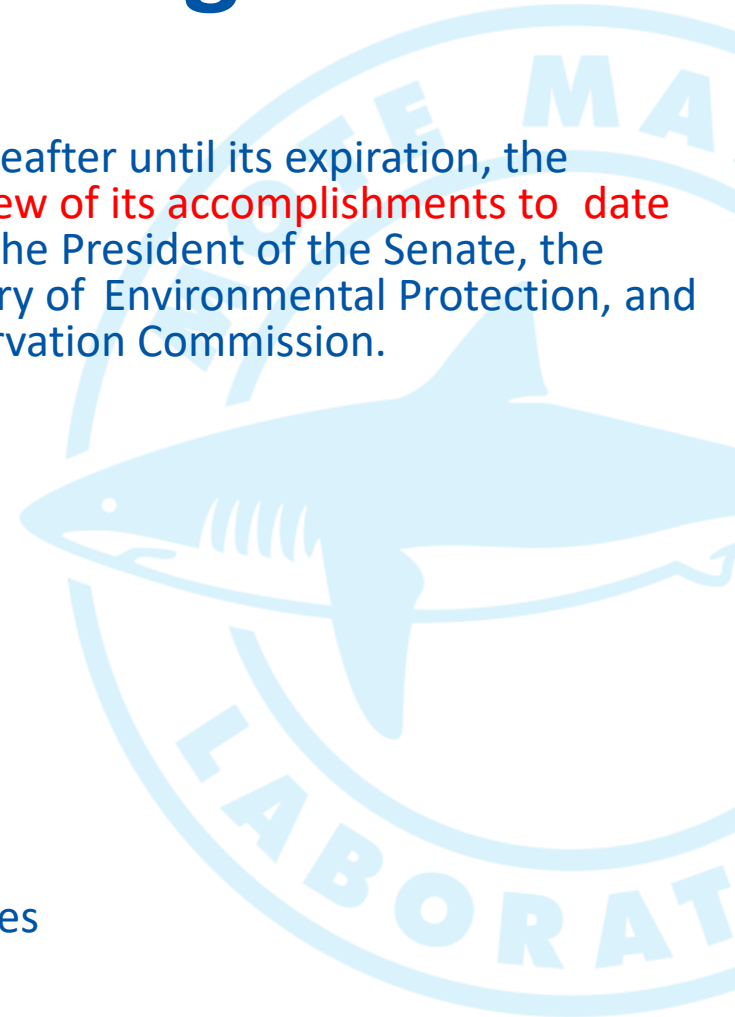
Required by subaward contracts from Mote

- **Mote Red Tide Initiative Website**

Technology Advisory Council Presentations and Minutes

Regular Updates

Project Summaries



Requests For Proposals

- 379.2273(2)(c)(1) Florida Statutes: Mote may use a portion of awarded funds to facilitate additional engagement with other pertinent marine science and technology development organizations...
- Open to any/all interested parties to **bring international best and brightest ideas**
- **Conducted 4 Requests for Proposals**
- **Coordinated effort** through partnerships and to **avoid duplication**
- Support not to exceed 1 year – **several continuing** via subsequent RFP/award
- Use of Mote facilities/infrastructure is **available at no charge**
- Partner Led Proposal Review Process:
 - **Diverse reviewer expertise** from NOAA, EPA, FWC, DEP, Universities, Estuary Programs, private consultants, and Mote
- **Future RFP's necessary/effective?**



Year 1 Projects

1. Kathryn J. Coyne, University of Delaware: *Optimizing production of a **dinoflagellate-specific algicide** for control of *Karenia brevis**
2. Sumit Chakraborty, Mote Marine Laboratory, *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*
3. Allen Place (Taylor Armstrong presenting), University of Maryland: *Pushing *Karenia* Over the Edge with Beer Derived **Flavonoids***
4. William Haskell, Mote Marine Laboratory, ***Automated in situ Advanced Sensing** Technology Development for Red Tide Mitigation and Control (PHySS-C)*
5. Vijay John, Tulane University: *A Thin Shroud with Integrated **Algaecide to Flocculate and Sink** *K brevis**
6. Richard Pierce, Mote Marine Laboratory, *Testing the **Efficacy of Products for Mitigating** Harmful Effects of *Karenia brevis* Red Tide Events along the Florida Gulf Coast*
7. Don Anderson, Woods Hole Oceanographic Institute: *Fate and Effects of *Karenia brevis* Cells, Toxins, and Nutrients Following **Clay Application** for Bloom Control*
8. Vincent Lovko, Mote Marine Laboratory, *Developing **UAV-based Red Tide Detection** System*
9. Michael Parsons, Florida Gulf Coast University: *Examining the Feasibility of **Removing and Composting Fish Carcasses** to Mitigate Red Tide*
10. Sarah Caywood and Aspen Cook, Mote Marine Laboratory, *Expansion and Updates to the **Beach Condition Reporting System***
11. Dana Wetzel, Mote Marine Laboratory, ***Natural Compound Control** and Mitigation for Red Tide*



Year 2 Projects

1. Neil Williams, nTec solutions LLC: *A Chemical-Free Red Tide Mitigation Technology Utilizing **UV-C LEDs***
2. Dr. Vincent Lovko, Mote Marine Laboratory, *BloomZoom: A Portable **Phone-based Microscope for Quantitative Detection** of *K. brevis* Through Citizen Science*
3. Alexis Wells Carpenter, AxNano LLC: *Evaluation of Controlled Release **Oxidants** for Red Tide Treatment and Mitigation*
4. Ralph Elliott, Ecological Laboratories: ***Microbe-Lift** Mitigation 96 Hour Testing with *K brevis**
5. Cynthia Heil, Mote Marine Laboratory, *Citizen Science Detection and Quantification of Florida Red Tides via Personal and **Smartphone-enabled PCR Technology***
6. Regina Rodriguez, Carbonxt: *In-situ Mitigation of Florida Red Tide via **Activated Carbon***
7. Cynthia Heil, Mote Marine Laboratory, *Evaluation of **QUAT Efficacy** for Red Tide Mitigation*
8. Annarie Lyles, Solaris Cybernetics, LLC: *Efficacy of **EVIE Robot** against *K. brevis**
9. Dana Wetzel, Mote Marine Laboratory, *A Rapid Field Red Tide Toxin **Biosensor for Commercially Important Shellfish and Seawater***
10. Jamie Lead, University of South Carolina: *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*
11. George Philippidis, University of South Florida: *Bioprospecting of natural **algicidal bacteria** associated with Harmful Algal Blooms to develop a sustainable mitigation strategy for red tides*



Year 3 Projects

1. Jennifer McCall, University of North Carolina at Wilmington, *Enabling **accurate field-based testing for shellfish farmers** with optimized toxin extraction and stable standards*
2. William Haskell, Mote Marine Laboratory, *Development of a low-cost propelled autonomous **underwater vehicle for red tide mitigation** and early response*
3. George Philippidis, University of South Florida, *Red tide mitigation through natural **algicidal bacteria** suppression of *K. brevis* during HAB progression*
4. Julia Darcy, AxNano LLC, *Controlled Release **Oxidants** for Red Tide Treatment and Mitigation*
5. Vijay John, Tulane University, *A Thin Shroud with **Integrated Algaecide to Flocculate and Sink** *Karenia Brevis**
6. Kathryn Coyne, University of Delaware, *Continued development of **bacteria-derived algicidal compounds** for mitigation of *Karenia brevis**
7. James Ivey, University of South Florida, **Karenia* Mitigation Platform: means and method for enhancing, vetting, and **deploying red tide mitigation** technologies within open water conditions.*
8. Donald Anderson, Woods Hole Oceanographic Institute, *Fate and Effects of *Karenia brevis* Cells, Toxins, and Nutrients Following **Clay***
9. Thoram Charanda, Prescott Clean Water Technologies, LLC, *Innovative Use of Advance **Oxidation, Nanobubble-Cavitation** for Rapid Deployment to Restore Severely Impacted Red Tide Areas Back to Natural Conditions*



Year 4 Projects

1. Michael Parsons, Florida Gulf Coast University: *Examining the Feasibility of **Removing and Composting Fish Carcasses: Phase II** to Mitigate Red Tide*
2. Danny Schillaci, Greenworld Environmental Alliance: *Evaluation Submittal for Red Tide Abatement and Prevention Technologies: **De-Oil-It***
3. Dana Wetzel, Mote Marine Laboratory, ***Natural algicides** from marine plants for targeted mitigation*
4. Shoutao Xu, Ecological Laboratories Inc., *Simulated Field Study (mesocosm and nearshore) of **Microbe-Lift PBL** plus **Microbe-Lift SA** or single product **ML/RTM3322** on *Karenia brevis**
5. Regina Rodriguez, Carbonxt, *In-situ Mitigation of Florida Red Tide via **Activated Carbon**, Phase 2*
6. Josh Mangum, Southwest Research Institute, ***Plasma Assisted Destruction** of *Karenia brevis**
7. Toufiq Reza, Florida Institute of Technology, *Simultaneous Adsorption of Red Tide and Brevetoxins on low cost **clay-biochar composite***
8. Stephen Rowley, Heartland Energy Group, ***Non-toxic biodegradable formulation** for mitigation of red tide cells and toxins*
9. Annarie Lyles, Solaris Cybernetics, *Optimizing **EVIE Robot technology** to mitigate *K brevis**
10. Thoram Charanda, Prescott Water Technologies, *Innovative Use of Advance Oxidation, Nanobubble-**Cavitation** for Rapid Deployment to Restore Severely Impacted Red Tide Areas Back to Natural Conditions*
11. Vijay John, Tulane University, *A New Approach to the **Flocculation, Sinking, and Targeted Destruction** of *Karenia brevis**
12. James Ivey, University of South Florida, *Harmful Algae Mitigation and Monitoring Environmental **Research Platform***
13. Allen Place, University of Maryland, ***Clay binding to luteolin and curcumin***
14. George Philippidis, University of South Florida, *Red Tide Mitigation with In-Situ **Low-Energy Electromagnetic Treatment** of Seawater*
15. Jamie Lead, University of South Carolina, *A **nano-enabled approach** to the aqueous phase removal of *Karenia brevis* and associated toxins*
16. Nicole Rhody, Mote Marine Laboratory, *Flushing Out Red Tide: Investigating Recirculating System Technologies for **Brevetoxin Elimination from Shellfish***
17. Cindy Heil, Mote Marine Laboratory, *Mitigation of Brevetoxin Aerosolization by **Dissolved Humic Substances***



GEA Red Tide Algae and Relaxed Toxins Abatement Initiative

Principal investigator: D. Schillaci, Greenworld Environmental Alliance

Summary:

- “De-Oil-it”, a hydrocarbon biodegrader solution, as a mitigation product for red tide
- De-Oil-It is EPA approved, typically used to break down oil and fuel spills by degrading hydrocarbons into less toxic chemicals
- Greenworld Environmental Alliance tested De-Oil-It on red tide cultures, successfully eliminating both cells and toxins
- meeting with DEP later this month



Adsorption of Brevetoxins on Low-Cost Biochar

Principal investigator: T. Reza, Florida Institute of Technology

Summary:

- use of clay modified with biochar to remove red tide cells and toxins
- biochar is a carbon-rich solid product traditionally used for carbon sequestration and water purification, but has recently been shown to absorb toxins from harmful algal blooms
- previous studies confirm that clay can effectively remove *K. brevis* cells during flocculation, however brevetoxin concentrations remain high, the addition of biochar is anticipated to remove the remaining toxins from the water column
- researchers are testing the clay-biochar complex in benchtop and 80-liter column studies to evaluate the adsorption of brevetoxins



Plasma-Assisted Destruction of *Karenia brevis*

Principal investigator: J. Mangum, Southwest Research Institute

Summary:

- plasma-based mitigation of red tide cells and toxins
- plasma technology has been found to act as a microbiological decontaminant, and has been used to treat algal blooms and disinfect fruits and vegetables
- when plasma interacts with water, it creates many reactive and oxidative species that can potentially eliminate red tide cells and toxins
- project will develop a portable plasma system and examine the best method to apply plasma-treatments to *K. brevis* in beaker-sized experiments



Non-toxic Biodegradable Formulation for Mitigation of Red Tide Cells and Toxins

Principal investigator: S. Rowley , Heartland Energy Group

Summary:

- investigate the effectiveness of “Xtreme”, a natural non-toxic product developed by Heartland Energy Group, on reducing red tide cells and toxins
- Xtreme is currently used for water purification and quality improvement applications, and has been shown to control blue-green algae blooms
- initial testing at Mote determined Xtreme significantly reduced red tide cells and toxins
- Researchers will now concentrate on finding the appropriate dosage of Xtreme needed for successful mitigation, as well as toxicity testing on representative marine species
- meeting with DEP later this month



Mesocosm Study of Red Tide Mitigation with Low-Energy Electromagnetic Treatment

Principal Investigator: G. Philippidis, University of South Florida

Summary:

- use low electromagnetic energy to restore water bodies with low oxygen and excess nutrients back to healthy aquatic systems
- lightweight solar-powered, free-floating, and remotely-controlled device that generates electromagnetic energy to continuously aerate water, restoring its natural properties
- this technology has already been successfully deployed in water reservoirs, lakes, and ponds, where it controlled algal growth, reduced odor, and restored and maintained aquatic health



Mitigation of Brevetoxin Aerosolization by Dissolved Humic Substances

Principal investigator: C. Heil and R. Pierce, Mote Marine Laboratory

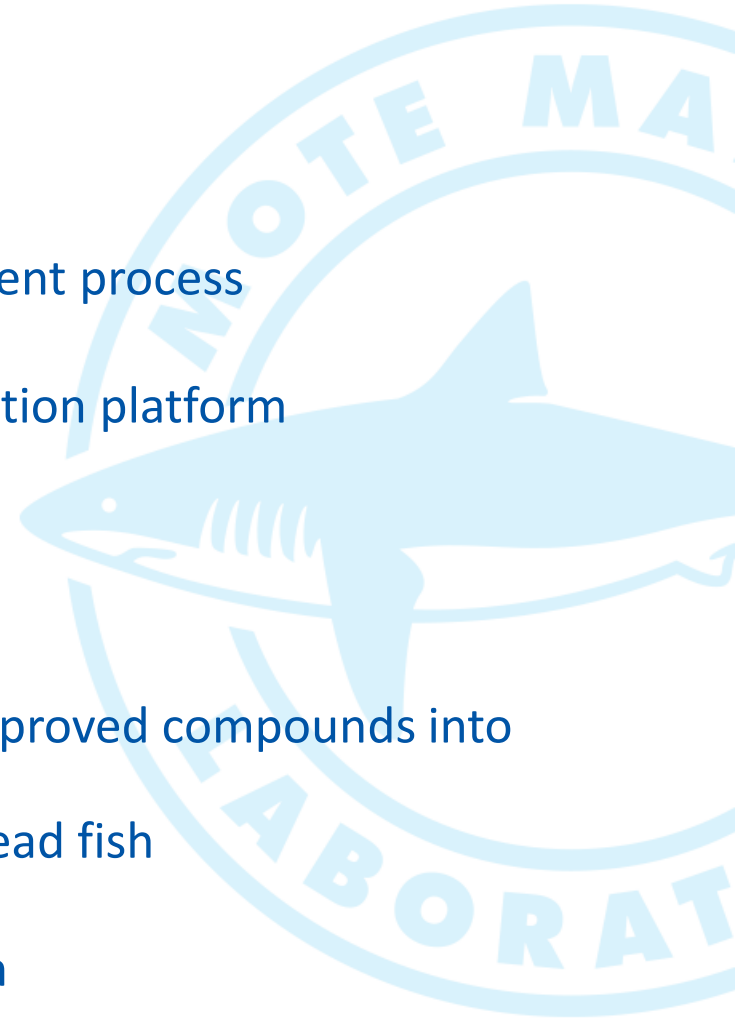
Summary:

- focusing on a method by which humic acids- naturally occurring, chemically complex mixtures of organic acids resulting from plant degradation- are added to waters containing a HAB to reduce production of aerosolized toxins
- application of dissolved humic compounds to *K. brevis* cultures in preliminary experiments have been shown to reduce the production of aerosolized brevetoxin by >99%
- this project seeks to identify a low-cost humic acid compound effective in mitigating the production of brevetoxin aerosols

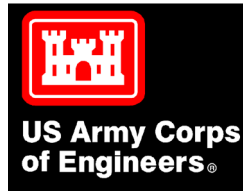


Promising Mitigation Tools

- encapsulated macroalgae compounds
- ozonation, cavitation, oxidation water treatment process
- UV-C radiation from LEDs
- quaternary ammonium compounds on mitigation platform
- Microb-Lift, Xtreme, and De-Oil-It
- algae-mitigating bacteria
- polymer-coated nanoparticles
- autonomous robot technologies
- curcumin, luteolin, or other natural or EPA approved compounds into flocculants, activated carbon, clay, or biochar
- commercializing removing and composting dead fish
- biosensor scanner for seawater and shellfish
- updates to Beach Condition Reporting System



Thanks to All Our Red Tide Initiative Research Partners



Red Tide Initiative – Looking Ahead

- 2023 Governor, Legislature, Agency Report
- Moving Projects to Tier 3 and 4
- Socialize Research Progress
- Build Off Aug 2022 Workshop
 - Deployment/Monitoring
 - Scalability
 - Economic Feasibility
 - Permitting/Compliance
 - Commercialization
- US HAB Control Technologies Incubator



Red Tide Initiative Workshop



US Harmful Algal Bloom Control Technologies Incubator



- Mote, University of Maryland, and NOAA
- \$7.5M for 5yrs with one \$7.5M 5 yr extension
- \$1M each year for national mitigation tools
- HAB mitigation tool and technology online database
- Regulatory Compliance by agency and state

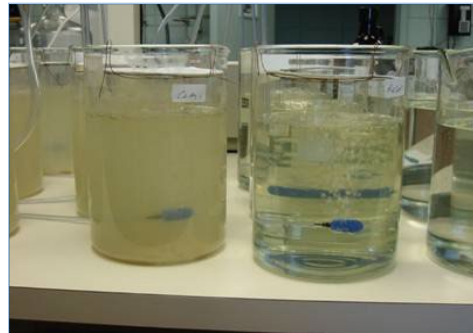
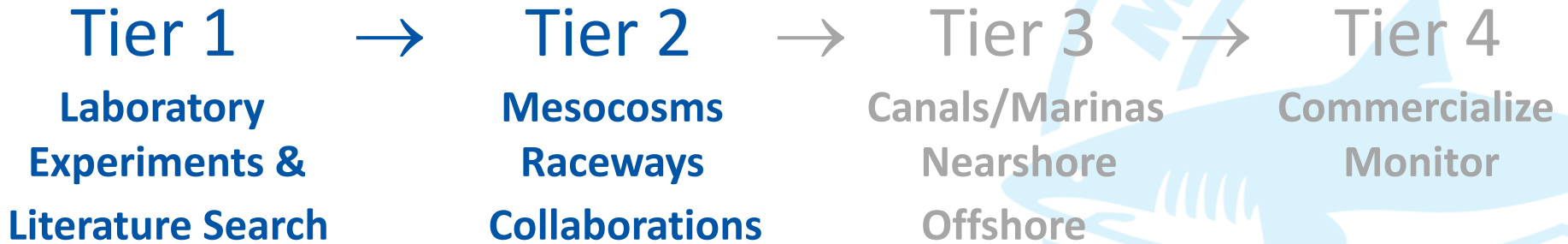
US Harmful Algal Bloom Control Technologies

Incubator Research Process



----- Incubator Funding -----

----- Other Funding -----



- Effects on the Cells and Toxins in the Lab
- Previous Uses Worldwide
- Existing Regulatory Approvals



- Effective with Natural Communities
- Ecological Impacts
- Human Health Concerns
- Logistical Issues
- Economically Feasible



- Pilot Studies
- Field Demonstrations
- Federal/State/Local Regulatory Approvals
- Engineering Needed
- Public Interactions



- Customers
- Intellectual Property
- Efficiency Scaling
- State/Local Budgets
- Deployment Contractors

Public Comments



TAC Member Comments



Thank You – Questions? Next TAC Meeting Summer 2023

