

NCCOS Annual Science Review: Harmful Algal Blooms and Hypoxia Program

Silver Spring, Maryland
28 - 30 November, 2023



NCCOS Annual Science Review: Harmful Algal Blooms and Hypoxia Program

Review Materials:

[Review Website](#)

[Briefing Book](#)

[Agenda](#)

[Biographies](#)

[Application of the NOAA Service Delivery Framework to Inform R2O Transition Planning \(video\)](#)

[ORTA Key Components of R2X \(video\)](#)



INTRODUCTIONS AND WELCOME!

Sean Corson, NCCOS Director



Agenda and Process for the Day

DAY 1 (Tuesday, 28 November 2023)

| | | | |
|---------------|--|-------------|--|
| 8:30 - 8:35 | Introductions and Icebreaker - <i>Sean Corson, NCCOS Director</i> | 1:00 - 2:45 | HAB Observing and Monitoring Presentation - <i>Greg Doucette, Research Oceanographer, HAB-M&R Branch; Marc Suddleson, Program Manager, CRP; Shelly Tomlinson, Oceanographer, HAB-F Branch</i> |
| 8:35 - 8:45 | Setting agenda and process for the day - <i>Lonnie Gonsalves and Dave Kidwell</i> | 2:45 - 3:00 | BREAK |
| 8:45 - 9:00 | High level recap of introductory information and videos - <i>Lonnie Gonsalves and Dave Kidwell</i> | 3:00 - 4:45 | HAB and Hypoxia Forecasts Presentation - <i>Alex Hounshell, Research Oceanographer, HAB-F Branch; David Scheurer, Oceanographer, CRP; Rick Stumpf, Oceanographer, HAB-F Branch; Quay Dortch, Senior HAB Scientist, CRP</i> |
| 9:00 - 9:30 | Graffiti board activity | 4:45 - 5:00 | Executive session - <i>Facilitated by Review Chair, Pat Brown</i> |
| 9:30 - 9:45 | BREAK | 6:00 | Dinner with panel at Mandalay in Silver Spring (930 Bonifant St, Silver Spring, MD 20910) |
| 9:45 - 10:15 | Overview of Feedback from 2018 HAB and Hypoxia Program Review - <i>Dave Kidwell, CRP Director; John Ramsdell, HAB-M&R Branch Chief</i> | | |
| 10:15 - 11:15 | Causes and Impacts of HABs and Hypoxia Presentation - <i>Maggie Broadwater, Program Manager, CRP</i> | | |
| 11:15 - 11:30 | Panel reflection time | | |
| 11:30 - 1:00 | LUNCH | | |

HABs and Hypoxia by the Numbers

A Review

HABS AND HYPOXIA PROGRAM REVIEW | NOVEMBER 28th - 30th | SILVER SPRING, MD

Congressional Direction- *Federal Appropriations*

- **Manage two separate lines of appropriations**
 - *Coastal Science, Assessment, Response and Restoration*
 - “Base appropriation”
 - \$55M in FY23
 - *Competitive Research*
 - Managed by Competitive Research Program
 - \$22.5M in FY23

Congressional Direction

- **Direction via HABHRCA and frequently in annual appropriations**
 - Accelerate deployment of effective methods of intervention and mitigation...
 - Understand causes and impacts...
 - Within CRP funding: “...not less than \$14M for HABs research..”

HAB-F

HAB Forecast Branch

- Develops and delivers ecological forecasts
- Conducts applied research needed to inform ecological forecasts
- Advances satellite methods for detecting HABs
- Helps stakeholders mitigate HAB impacts

HAB-M

HAB Monitoring & Reference Branch

- Produces reference methods, materials and validation
- Designs, fabricates and calibrates toxin sensors
- Advances HAB prevention and control technologies
- Establishes and transitions regional user laboratories
- Sustains citizen science for HAB monitoring and underrepresented communities

CRP

CRP HAB and Hypoxia Programs

- ECOHAB - Ecology and Oceanography
- MERHAB - Monitoring and Event Response
- PCMHAB - Prevention, Control, and Mitigation
- SEAHAB - Social and Economic Assessments (new)
Event Response
- Coastal Hypoxia Research

Strategic Approach

Observing

R&D

- Research and development of improved detection technologies and validation of data;
- Marine and freshwater satellite remote-sensing;
- PMN monitors marine and estuarine HAB species at over 250 coastal sites.

Operations

- NHABON Implementation Plan with IOOS

Forecasting

R&D

- Applied research needed to inform ecological forecasts;
- Advancing satellite methods for detecting HABs;
- Developing and delivering regional forecasts.

Operations

- Plan in development with IOOS



PCM

R&D

- Control advances promising technologies for preventing, controlling, or mitigating HABs;
- HAB Event Response provides enhanced monitoring and response to events;
- Prevention through understanding the causes and impacts of HAB events.

Questions.....

Additional Logistics

- WIFI
 - Guest Username: HABProgramReview
 - Guest Password: HABPR1315
- Review Website
 - [NCCOS HABs and Hypoxia Program Review](#)
- Zero Waste Kit
 - Reduce and reuse!
 - Place items in sink at end of use and Shelby will wash and dry for next day

Graffiti Board Activity

Peg Brady, Facilitator
Shelby Butz, Review Coordinator



Graffiti Board Activity

- Break into groups of three
- Prompt: “What are you most looking forward to learning, sharing, digging into this week?”
 - Bonus points: Draw a review mascot.
- 10 minutes for writing ideas on sticky pad
- Select representative from each group for sharing

15 min Break!

Return by 9:45 AM



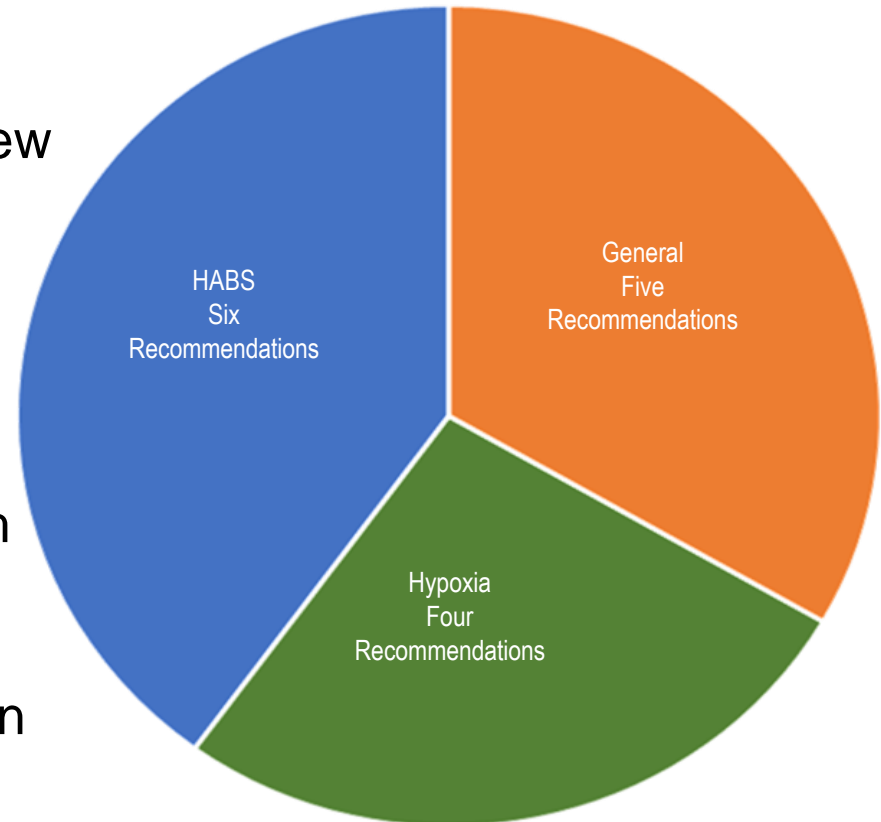
2018 HAB/Hypoxia Program Review: Recommendations and Actions

Dave Kidwell and John Ramsdell



Overview

- A compilation of reviewers' comments was submitted by the chair of the review panel on May 8, 2018.
- NCCOS consolidated into 20 recommendations for a coherent statement on the topic
- NCCOS staff provided a response narrative for 15 recommendations with action items.
- Five recommendations were deemed not appropriate for identifying an action item (i.e., progress was already being made on the subject of the recommendation).



HAB Recommendation: Revise or produce a different HARRNESS report

NCCOS Response: NCCOS recognizes that this is an important topic that should be discussed within the IWG-HABHRCA, as well as in consultation with the university community and other stakeholders.

Actions 2018-2023:

- HARRNESS 2020-2030 plan has been completed and building on major accomplishments from past efforts, provides a state of the science update since the previous decadal HARRNESS plan (2005-2015), identifies key information gaps, and presents forward-thinking solutions

HAB Recommendation: Reconsider “biological controls” as important HAB remediation tools, including efficacy of products currently available

NCCOS Response: Biological intervention is an approach to controlling HABs, with the others including chemical and physical intervention. The use of biological controls must be approached with great caution.

Actions 2018-2023:

- Embraced chemical and biological control research as a potential control solution
- CRADA between NOS and AMURI for Nanobubble Ozone Technology, 2019
- Regional biocontrol project (DinoSHIELD) funding, 2020
- US HAB Control Technologies Incubator Funding, 2022
- Provisional Patent Awarded to CRADA, 2023

HAB Recommendation: Event Response Program needs to be funded at a much higher level

NCCOS Response: The ART continues to provide coordinated assistance to coastal managers during HABs and related health incidents. The current bills for reauthorizing HABHRCA (S 1057 and HR4417) include a section on providing responses to HAB and Hypoxia Events of Significance.

Actions 2018-2023:

- NCCOS provides integrated response capacity; satellite monitoring, toxin analysis, and funding
- CRP Event Response Program increased to \$100K annually
- NCCOS led the IWG - HABHRCA IWG to host a Federal HAB-Related Biospecimen Lab Inventory
- NOS initiated CRADAs for a network of user laboratories to conduct regional toxin monitoring

HAB Recommendation: The Phytoplankton Monitoring Network (PMN) should be more strategic in program expansion

NCCOS Response: The PMN has improved its strategic recruitment of volunteer groups in high-priority HAB impacted regions of the country.

Actions 2018-2023:

- NCCOS funded five year program to develop an aquaculture PMN Empower shellfish farmers with advance warning of HABs, mitigate the threat of HABs, and minimizing economic losses to the aquaculture shellfish industry, 2021
- NCCOS funded a two year program to increase STEM diversity in Latino communities 2021
- NCCOS collaborated with EPA Managing Harmful Algal Blooms in Tribal Waters Webinar Series, 2021
- NCCOS receives diversity and inclusion grants for PMN to include lower income urban and rural communities, 2022,2023
- NCCOS funded work to promote Inclusion of Sensory Impaired Individuals in NOAA Citizen Science 2023

HAB Recommendation: NCCOS should focus on developing observational and monitoring technologies that are easily transferable to, and affordable by, non-federal entities.

NCCOS Response: Developing better monitoring and observing capabilities and technologies is a very high priority for NCCOS. The Environmental Sample Processor (ESP) has been an NCCOS focus for autonomous toxin sensor development during the past five-years. This has been a joint effort with the intramural and extramural programs and many other partners.

Actions 2018-2023:

- Initiation of partnership with MBio Diagnostics (now LightDeck) to evaluate planar waveguide technologies, 2018
- Initiation of partnership with MBARI for toxin detection capability to ESP downsized to “tackle box”, 2018
- NCCOS Funding for “Right Sizing HAB Sensors” 2020 to adapt ESP core processor to SPR, 2020
- NCCOS releases R2A Video on “Toxicity of Lake Erie Algal Bloom in Near Real-Time”, 2020
- ECOHAB AND MERHAB funding to LightDeck, 2020

HAB Recommendation: Conduct studies that improve socioeconomic understanding of impacts from HABs

NCCOS Response: NCCOS agrees that there is a need for better estimates to compare the costs and benefits of various mitigation strategies following HAB [or hypoxia] events. .

Actions 2018-2023:

- Funded two economic impact projects following large and prolonged FL red tide event
- Funded and collaborated to hold a HAB economic impact workshop
- Collaborated in development of “Hitting Us Where it Hurts” story map
- Initiated the Social, Cultural, and Economic Assessment of HABs funding program

Hypoxia Recommendation:
NCCOS should focus on developing observational and monitoring technologies that are easily transferable to, and affordable by, non-federal entities.

NCCOS Response: NCCOS will continue to engage with the HTF on monitoring and other Federal and State efforts, and improve coordination with internal and external monitoring programs.

Actions 2018-2023:

- Continued to support ship-based annual monitoring cruise
- Provided oversight and technical support for a suite of autonomous vehicle development projects
- Collaborated with OMAO's uncrewed systems program to test applicability of surface vehicles.

General Recommendation: Engage and collaborate with other agencies to avoid duplication and define respective roles and responsibilities more clearly.

NCCOS Response: NCCOS agrees...

Actions 2018-2023:

- Increased staff support and coordination through the IWG-HABHRCA
- Established a MOU in FY19 with the U.S. Centers for Disease Control and Prevention
- Collaborated with USACE, EPA, USGS, and NASA to develop CYAN
- Actively coordinates funding and projects with USACE, particularly for HAB control

External Factors Influencing Action Status

Over the intervening time, our actions have necessitated adaptation

- Congressional direction - Feedback from briefings and appropriations language
 - e.g., focus on socioeconomic impacts
- Evolving stakeholder needs
 - Maturing technologies, emerging species, and climate
- Regulatory landscape
 - NEPA has limited our ability to significantly advance biological controls
- HAB events

Open Discussion

External Peer Review: Harmful Algal Blooms and Hypoxia Portfolio

February 26-28, 2018

NCCOS Response to Review Panel Recommendations

October 30, 2018

Link to all recommendations/actions:

<https://docs.google.com/spreadsheets/d/1Q1XH0P9iR2M6qip2Uy8hJ07AfCWblAGYqpp22N2Z3es/edit?usp=sharing>

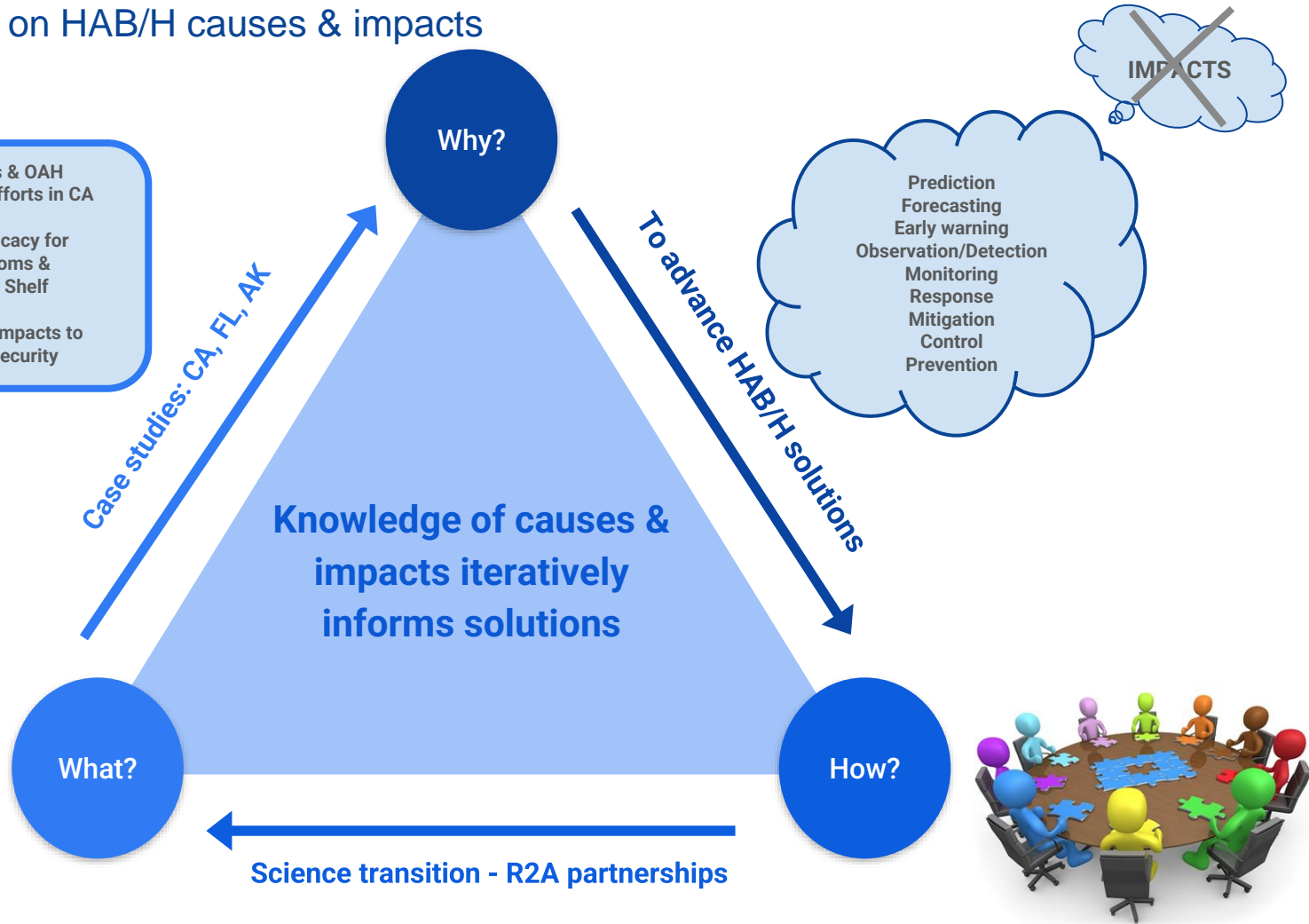
HABs & Hypoxia Understanding Causes & Impacts to Advance Solutions

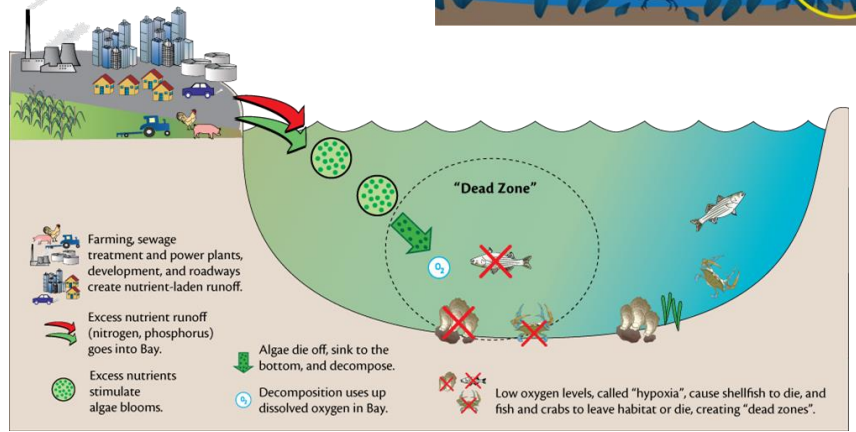
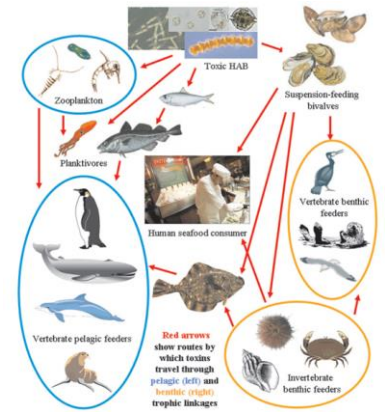
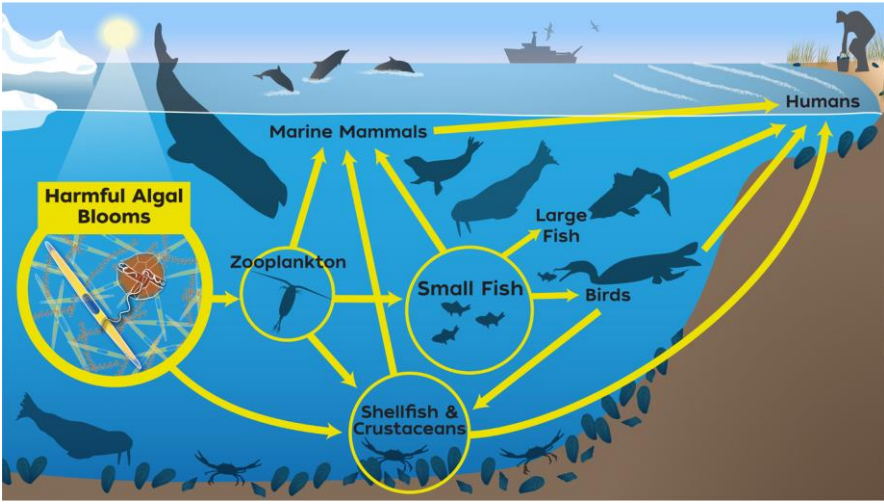
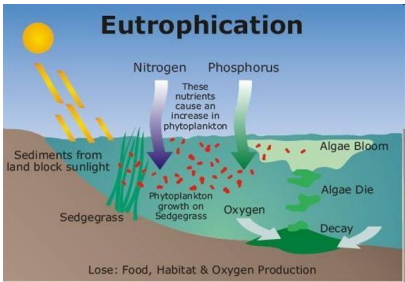
Maggie Broadwater, PhD
NCCOS Competitive Research Program



Outline: Research on HAB/H causes & impacts

- 1. A holistic approach to HABs & OAH informs WQ management efforts in CA
- 2. Improving management efficacy for recurrent *Karenia brevis* blooms & hypoxia on the West Florida Shelf
- 3. Shifting focus in AK - HAB impacts to subsistence food safety & security





ADVISORY

MODERATE HEALTH RISK

HARMFUL ALGAL BLOOM (HAB)

FLORACIONES DE ALGAS NOCIVAS

Always keep children and pets away from areas with blooms or runoff.

WARNING

Do not harvest mussels here. Mussels are not safe to eat. Toxins are not destroyed by cooking. Do not use for bait.

Sources: New Jersey Department of Environmental Protection (left) and Oregon Department of Agriculture (right). | GAO-22-10449



R2A: It's about the partnerships

MAKING INTENTIONAL CONNECTIONS AMONG PARTNERS, PURPOSE, ACTIVITY, AND APPROACH

WHO?

Who are the **partners** and what are their expectations for participation?

WHY?

What is the **purpose** of the partner's participation?

WHAT?

What **activity** are the partners participating in?

HOW?

What **approach** fosters the appropriate level of partner participation?

Source: Carson et al. 2022; <https://doi.org/10.1029/2022csj000001>

ALERT

INFORM

INVOLVE

COLLABORATE

CO-CREATE

OUTREACH



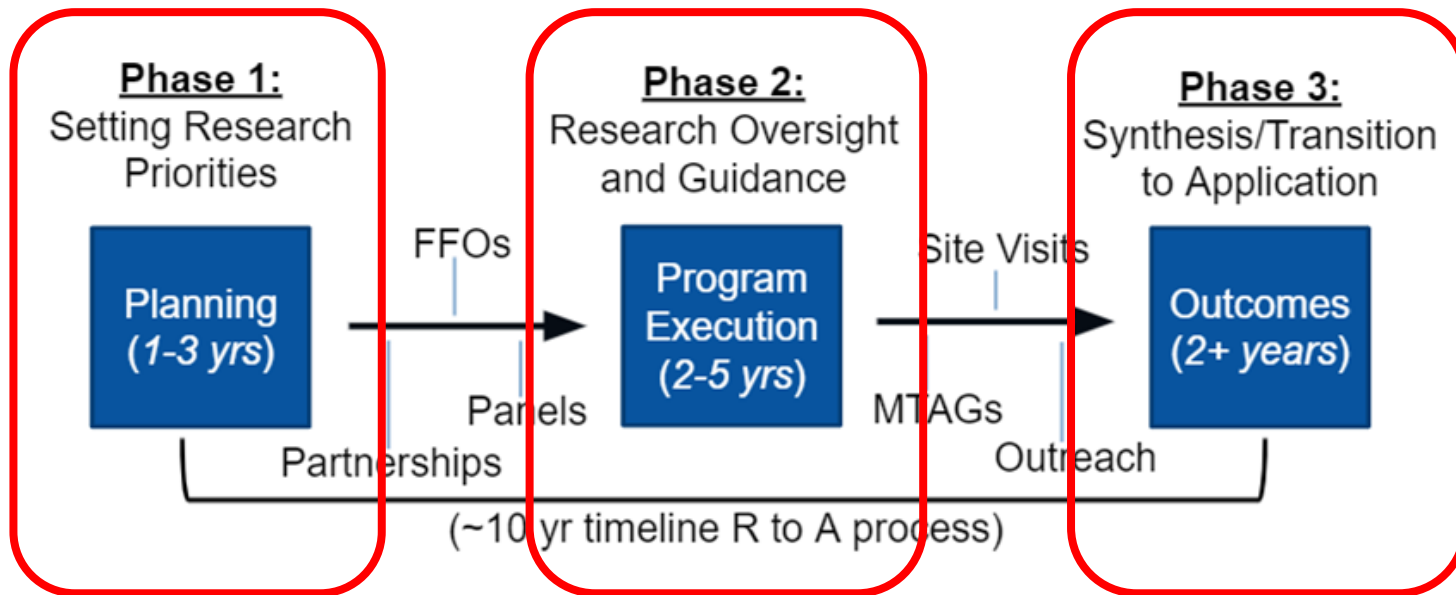
Continuum of partner participation



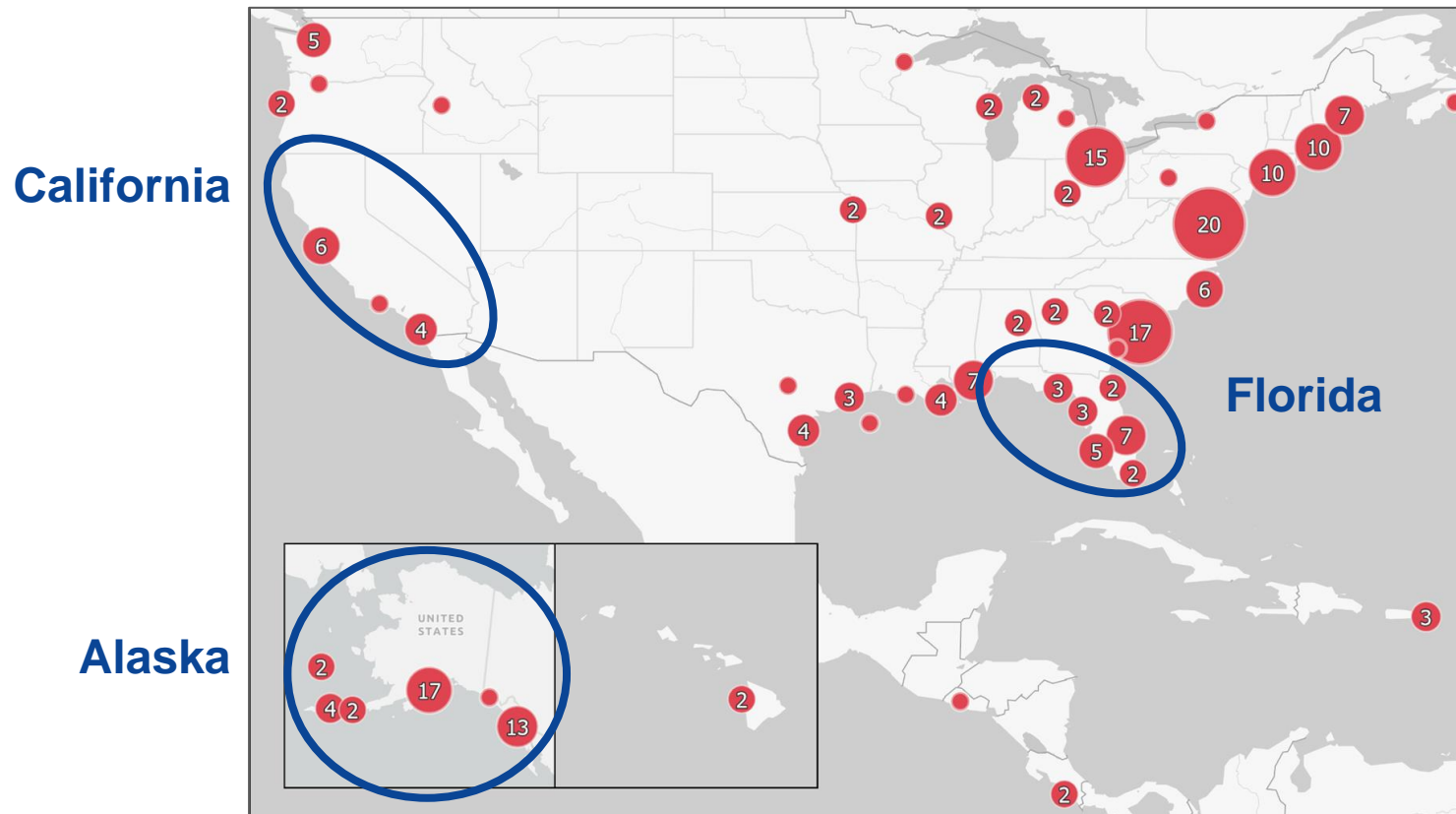
ENGAGEMENT

Source: Carson et al. 2022; <https://doi.org/10.1029/2022csj000001>

Science transition approach



Example - [NCCOS Research Provides Scientific Foundation for U.S. Supreme Court Ruling \(NCCOS News\)](#)



California

A holistic approach to HABs & OAH informs management



UNIVERSITY
OF
CALIFORNIA



SOUTHERN CALIFORNIA
COASTAL OCEAN
OBSERVING SYSTEM



CENTRAL & NORTHERN
CALIFORNIA OCEAN
OBSERVING SYSTEM



IOOS
Integrated Ocean
Observing System



SOUTHERN CALIFORNIA
COASTAL WATER
RESEARCH PROJECT

A PUBLIC AGENCY FOUNDED 1969

Applying next-generation science to aquatic ecosystems management



CALIFORNIA
OCEAN
PROTECTION
COUNCIL



West Coast
OCEAN ALLIANCE

NCCOS R2A timeline: Causes & impacts of HAB/H events in California

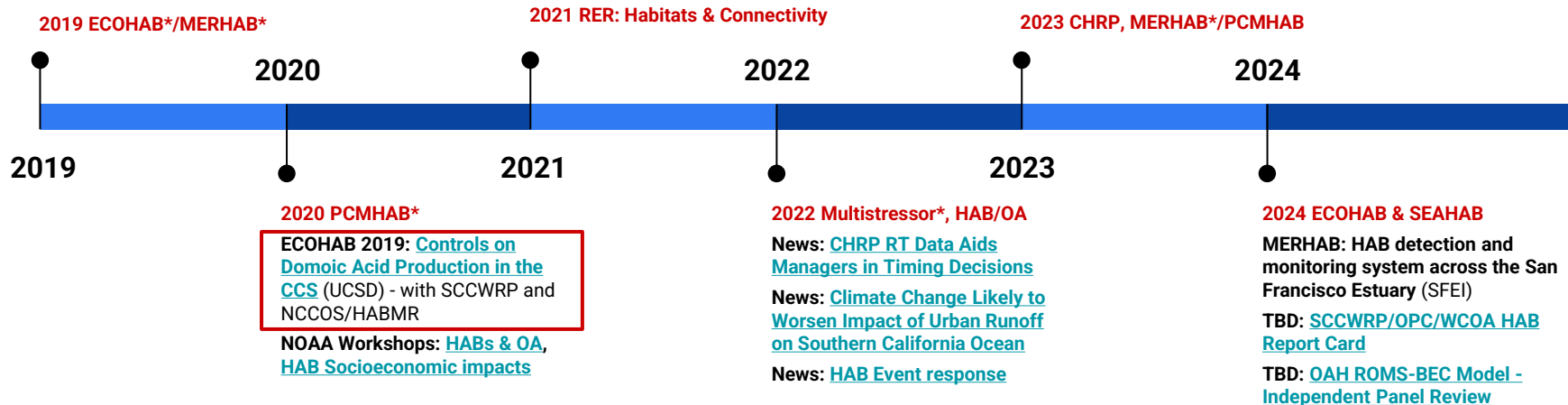
Pre-2019

- SDI/HABMR Projects: [Marine mammal impacts from recurrent DA events & UMEs](#) - with TMMC & NOAA OPR
- MERHAB 2005: [RAPDAlert: Pseudo-nitzschia & domoic acid](#) (USC) - with SCCWRP
- ECOHAB 2011: [Comparison of Upwelling and Coastal Land Use Patterns on the Development of HAB Hotspots](#) (UCSC) - with SCCWRP
- News: [2015 West Coast HAB Event Response](#) - "the Blob"
- MERHAB 2015: [Monitoring Multiple HAB Toxins at the Land-Sea Interface](#) (SCCWRP)
- OA 2015: [Modeling OAH to Support Ecosystem Prediction and Environmental Management in the CCS](#) (UCLA) - with SCCWRP
- CHRP 2018: [Biological Vulnerability to Hypoxia in the CCS](#) (UW) - with SCCWRP & OPC
- CHRP 2018: [Causes and Consequences of Hypoxic Events in Low-Inflow Estuaries](#) (UCSD)
- MERHAB 2019: [Emerging Algal Toxins in the California Current System](#) (UCSC) - with SCCWRP

ECOHAB 2018: [Can Management Actions Influence HAB Toxins in the CCS?](#) (UCLA) - with SCCWRP

NOAA Workshop: [Sanctuaries & Climate Change](#)
PCMHAB 2020: [HAB Community Technology Accelerator](#) (SCCOOS & CenCOOS)

News: [NCCOS-MBARI-Scripps LRAUV field deployment](#)
SCCWRP Workshop: [CA HABs & OAH](#)
News: [HAB Event response](#)



Future

- Multistressor research to improve predictions
- Model validation - increasing focus on prevention where appropriate
- Continued engagement with SCCWRP, OPC & partners

R2A: Causes & impacts of CA *Pseudo-nitzschia* blooms & DA events

WHY? - DESIRED PRODUCT/SERVICE

Quantitative understanding of the oceanographic, cellular, and anthropogenic factors that regulate CA *Pn* blooms and DA events

WHO? - TARGET USER GROUP

WQ & natural resource managers:
 SCCWRP, OPC, WCOA, CA Water Boards, POTWs
 —
 R2A - Early warning, mitigation,
 informing prevention strategies

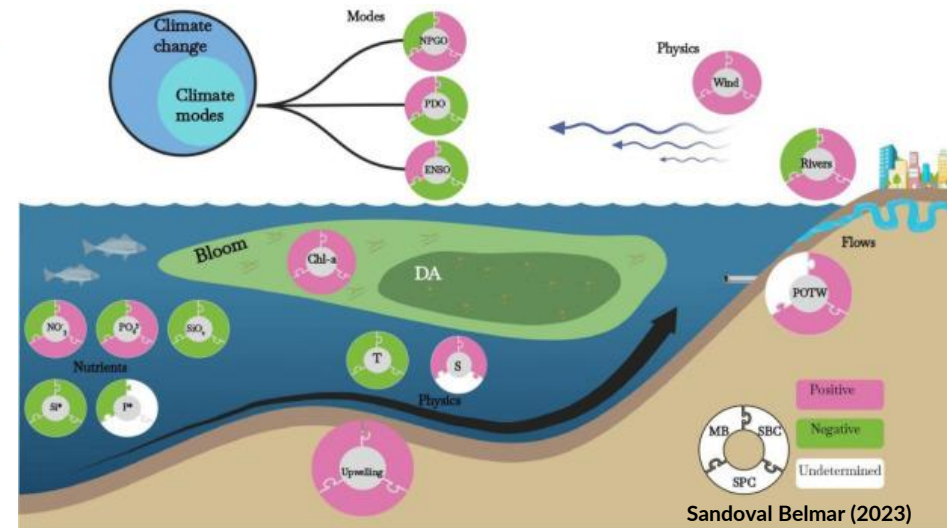
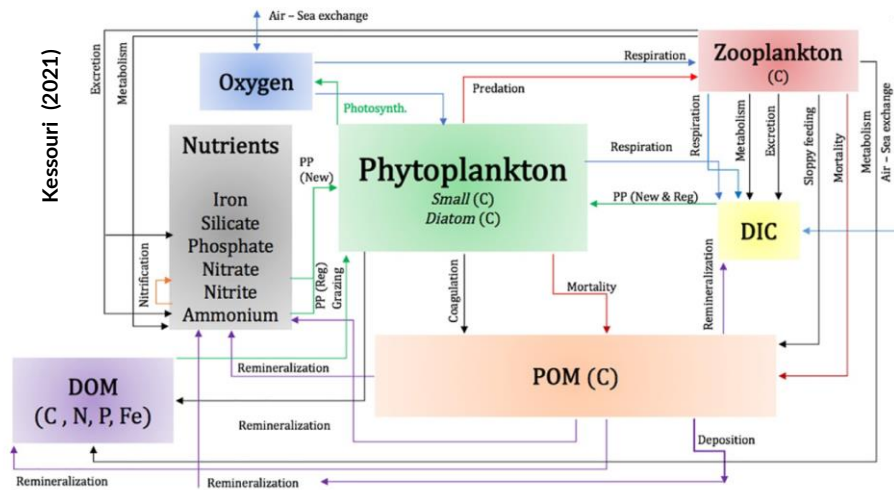
WHAT? HOW? - CURRENT STATE OF PRODUCT/SERVICE

- Predict: ROMS-BEC-*Pn* model for S-CCS
- Understanding offshore vs coastal drivers → management interventions
- Localized effects vs. global climate drivers
- DA biosynthesis - Predicting toxicity
- DA thresholds for impacts to marine mammals
- Related products: C-HARM; California HABMAP; California IFCB network, Dashboard & HABDAC; California HAB Bulletin
- Early warning, mitigation, prevention

WHO? - NCCOS ORGANIZATION UNITS & KEY PARTNERS

CRP & SDI/HABMR
 —
 UCSD/Scripps, UCSC, UCLA, USC, MBARI, SCCOOS,
 CenCOOS
 —
 R2A: SCCWRP [OPC, WCOA]

Outputs/Outcomes: Model application to water resource management



- ROMS-BEC-Pn: Multistressor understanding of *Pn* bloom dynamics (offshore vs coastal drivers) leading to appropriate management interventions
- Regulatory agency acceptance - OPC & State/Regional Water Boards
- January 2024: Model review by independent panel
- Prevention strategies - future evaluation using WCOA HAB & OAH report card system

SCCWRP FACT SHEET

Modeling as a tool to support coastal water-quality decisions

A primer on how computer modeling is used to understand the effects of discharging nutrients to Southern California's ocean

When coastal communities face water-quality problems, they often struggle to understand the extent of the problem across space and time. Environmental monitoring programs can provide some insights, but only for a limited number of sites at discrete time points.

Moreover, as communities identify possible solutions over time to solve water-quality problems, they need assurances they'll get tangible environmental benefits – before investing millions or even billions of dollars in a particular solution. Monitoring programs can quantify the success of these solutions once implemented, but do not provide insights about the likelihood of success for solutions that have yet to be implemented.

Modeling helps communities make informed choices

For decades, managers have relied on computer modeling to generate a more comprehensive picture of coastal ecosystem health and to evaluate if proposed interventions to protect water quality will be effective. Through modeling, stakeholders can:

- Weigh the benefits vs. costs of different possible interventions
- Consider the risk of taking no action vs. taking action that turns out to be wrong or inadequate
- Use a common set of facts and data to reach consensus on the best course of action

Examples: Modeling informing decisions

Managers routinely use proven computer models as a basis for taking action:

- » During hurricanes, weather forecasting models help public officials determine when and where to issue evacuation orders to move millions out of harm's way.
- » When a body of water needs to go on a "pollution diet," water-quality models help predict how much pollution levels need to be reduced to restore healthy conditions for plant and animal communities.
- » Policymakers rely on global climate models to understand how Earth's climate will change in the future and how reducing carbon emissions could slow these changes.



Human activities on land can adversely affect the health of aquatic resources, including Southern California's coastal ocean, above. Coastal communities rely on computer modeling to better understand these problems and evaluate if proposed interventions will be effective.

Should a model's predictions be trusted?

*"All models are wrong; some are useful."
 –British statistician George Box*

All models generate predictions with some degree of error, which can lead to questions about how much their predictions can be trusted. The key to developing confidence in a model's predictions is to scrutinize how a model is performing – a critical step known as quantifying modeling uncertainty. When managers understand modeling uncertainty, they have context for deciding how much confidence to place in what the model is predicting.

» Uncertainty is not unique to modeling

All types of scientific measurements have uncertainty. Field and satellite measurements – often held up as the gold standard for assessing coastal water quality – have uncertainty too. The main difference is scientists have an easier time quantifying uncertainty in monitoring data than in models.

» How modeling uncertainty is quantified

Scientists commonly quantify modeling uncertainty in multiple ways, including:

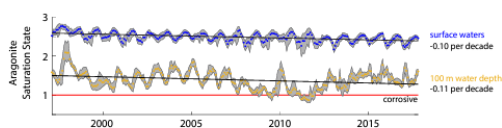
- Comparing the model's predictions to field data; any difference represents the model "uncertainty," which is a combination of error in the model's predictions and error in field measurements
- Conducting a sensitivity analysis, where the data that are fed into the model are intentionally tweaked to determine how vulnerable the model's outputs are to various modeling assumptions
- Running a model comparison analysis, where the model is compared to other models that predict similar variables to identify differences in their predictions

The more ways that modeling uncertainty gets quantified, the more confidence that managers can have in the model's predictions – and thus the more likely managers are to make informed decisions based on modeling insights.

Case study: Modeling the effects of nutrient discharges on Southern California coastal waters

Southern California communities face a conundrum

Increased greenhouse gas emissions are warming Earth and causing ocean pH and oxygen levels to fall along the West Coast, leading to widespread problems for marine life. Although greenhouse gas emissions are viewed as the primary driver of these changes, scientists are studying the extent to which nutrients discharged from heavily populated Southern California coastal communities could be exacerbating these problems. Computer models are foundational to these investigations; the outcomes could have significant cost implications for communities.



Modeling is used to simulate multiple aspects of coastal ocean health, including changes in a property of seawater chemistry known as aragonite saturation state, above, at two different depths over time.

Key management questions

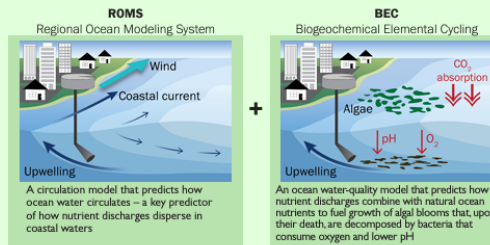
As scientific understanding of the effects of coastal nutrient discharges improves, Southern California will be faced with tough questions about whether to act – and the costs of action vs. inaction:

- » Will investing in reducing nutrient discharges make a measurable difference for coastal ocean health?
- » How could nutrient reductions result in measurable changes in coastal water quality?
- » Are there nutrient management alternatives – such as offshore kelp farming – that could measurably improve coastal water quality?

How the coastal water-quality model works

Southern California's coastal water-quality model is made up of two component models – collectively known as ROMS-BEC – that work in tandem to predict the influence that local nutrient discharges are having on coastal ocean health.

Southern California's ROMS-BEC coastal water-quality model



» Assessing influence of local human discharges

Scientists are using the model to predict how coastal ocean health is affected by local nutrient discharges, then repeating the modeling simulation – except this time, reducing local nutrient discharges. The difference between the two simulations represents how much nutrient discharges have the potential to alter coastal ocean pH and oxygen levels.

» Evaluating effectiveness of possible interventions

Just as scientists are working to model what is happening now, models also have the potential to help understand the effectiveness of possible future nutrient management decisions. Scientists are using ROMS-BEC to simulate the combined effects of these potential management scenarios and projected future local and regional changes to ocean pH and oxygen levels driven by climate change.

Building management confidence in modeling

To build confidence in the ROMS-BEC model's predictive abilities, scientists are quantifying uncertainty in multiple ways, including:

- Comparing hindcast modeling of algal blooms, pH and oxygen levels in coastal waters to more than 20 years of corresponding field monitoring data (see "More reading" links below), focusing on areas where nutrient reductions have already occurred to assess model performance
 - Partnering with stakeholders to invite outside experts to independently review the ROMS-BEC modeling work and evaluate modeling uncertainty
- These and other model validation activities are ongoing.

More reading

- [Findings of ROMS-BEC water quality application](#)
- [Findings of model skill assessment](#)



California case study overview

Quality

- Scientists recognized as national and international leaders
- **New and validated technologies (models, LRAUV/ESP, Wirewalkers)**
- **30 peer-reviewed publications to date (2 ECOHAB projects) - more in progress**
- Multiple funding sources including CHRP & National Competitive HAB program funding (ECOHAB, MERHAB, PCMHAB) - Competitive merit review by expert panel, relevance, scientific/technical merit (70%)
- **Leveraging OPC, SG, NIEHS, NASA & other funding streams**

Performance

- Addressing HABHRCA & Action strategy recommendations
- **SDI/HABMR project participation (Doucette & Mikulski) - Sensors**
- CRP PMs actively participate in project meetings, external communications
- **Project team/partners active in US NHC, NHABON, GOOS, GlobalHAB, IOC & UN Decade initiatives**
- **SCCWRP - direct link to users and active participation in R2A**
- NCCOS leadership: 2020 OA/HAB workshop, 2021 NMS Climate Change Science Priorities Workshop

Relevance

- Research products directly inform improvements to HAB/H management & response
- CA is leading holistic, multistressor research applications (HABs & OAH)
- **Predicting toxicity to inform strategies for early warning & mitigation, preparedness & response**
- **Source attribution to inform strategies for prevention via nutrient management**
- **Multiple products targeted to specific end users**
- **Focus on interpretation of results (R2A)**

Florida

Recurrent *Karenia brevis* blooms & hypoxia
on the West Florida Shelf - Improving management efficacy



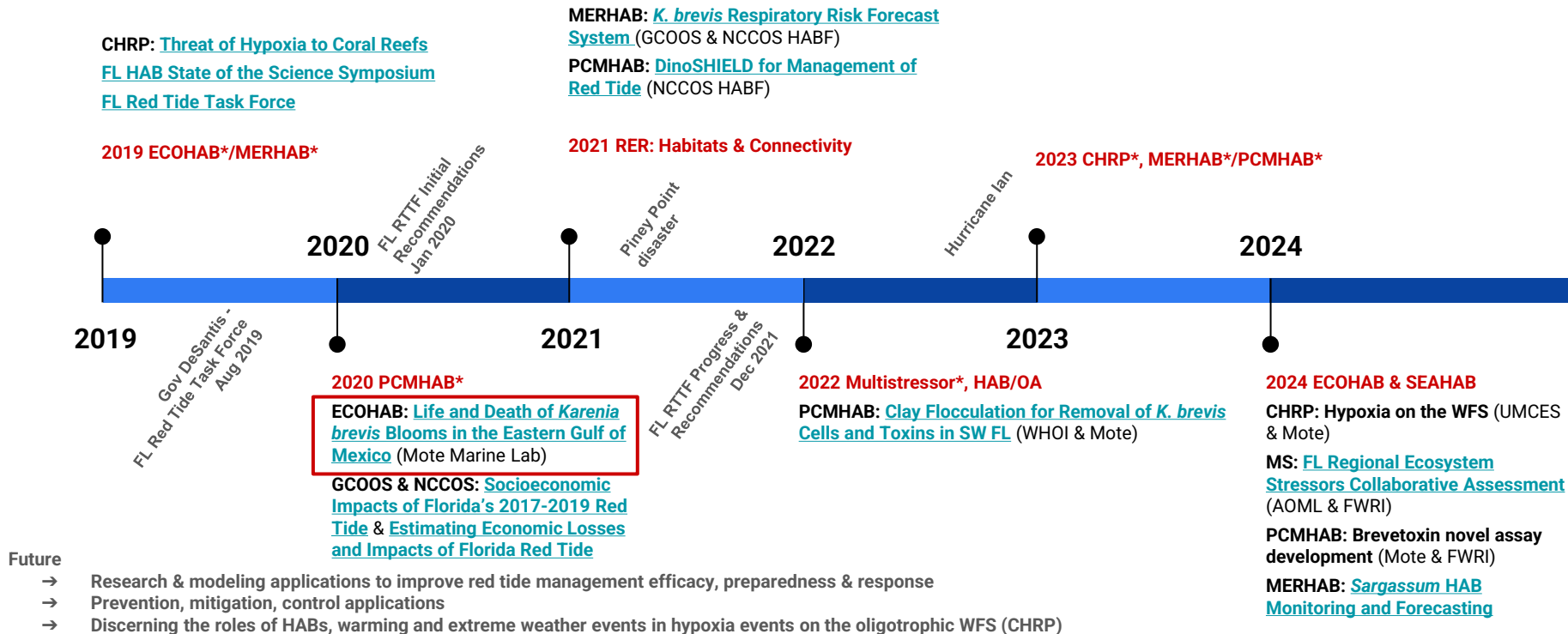
**Florida Fish and Wildlife
Conservation Commission**

FWC Fish and Wildlife Research Institute

NCCOS R2A timeline: Causes & impacts of Florida *K. brevis* blooms

Pre-2019

- 1997 ECOHAB Florida (FWRI) & 1998 Eco-Sim-WFS (USF)
- 2006 ECOHAB: [Karenia Nutrient Dynamics in the Eastern Gulf of Mexico](#) (FWRI & Mote)
- 2017 PCMHAB: [Alternative Method for NSP Monitoring and Management](#) (FWRI)
- 2017 ECOHAB: [Mechanism Based Intervention for Brevetoxin Induced Oxidative Stress](#) (FIU & Mote)
- 2018 News: [NCCOS, Partners Respond to Prolonged Florida Red Tide](#)

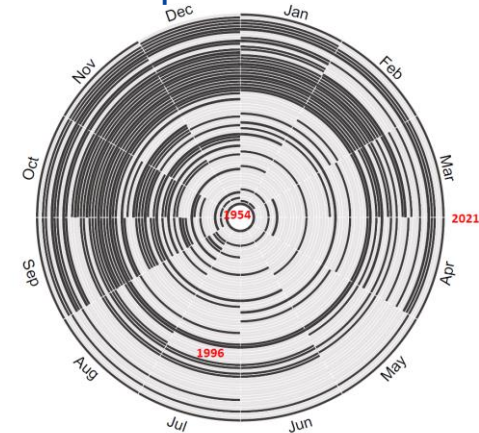


Life and Death of *Karenia brevis* Blooms in the Eastern Gulf of Mexico

| | |
|---|---|
| <p>WHY? - DESIRED PRODUCT/SERVICE</p> <p>Improve FL red tide management efficacy</p> | <p>WHO? - TARGET USER GROUP</p> <p>Florida coastal communities Coastal resource managers Industry: aquaculture/shellfish/tourism — R2A - Management, mitigating impacts, communication</p> |
| <p>WHAT? HOW? - CURRENT STATE OF PRODUCT/SERVICE</p> <p>Field/Lab Studies & Modeling to inform:</p> <ul style="list-style-type: none"> → Longer-term prediction → Mitigation of economic impacts → Effect of physical factors/nutrients/extreme events on <i>Kb</i> bloom variability → Bloom dispersal/termination → <u>Management & mitigation of impacts</u> | <p>WHO? - NCCOS ORGANIZATION UNITS & KEY PARTNERS</p> <p>CRP & SDI/HABF — Mote Marine Lab, UMCES, NYU, USF, Bigelow Laboratory, UF — FL FWRI GCOOS & SECOORA SFWMD Ocean Era (Offshore Aquaculture Demo Project)</p> |

Outputs/Outcomes: Research informing state, local stakeholders & public interest

- Assessing the role of climate factors in driving *Kb* bloom occurrence & severity
- What is the role of climate in regulating bloom severity, duration and the occurrence of unusual summer blooms?
 - ◆ FWRI HAB historical database
 - ◆ *Kb* bloom severity index
- ROMS-RCA-MIXO modeling of *Kb* blooms
- Piney Point event support
- Hurricane Ian & 2022-2023 FL red tide
- Public attention - Spring Break & 2022-2023 FL red tide
- Media communications
- Ocean Era offshore aquaculture siting



Representation of Florida FWRI HAB historical database 1954-2021 (Heil, ECOHAB Annual Report 2023)

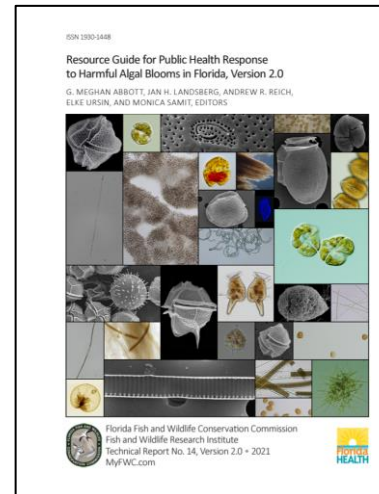
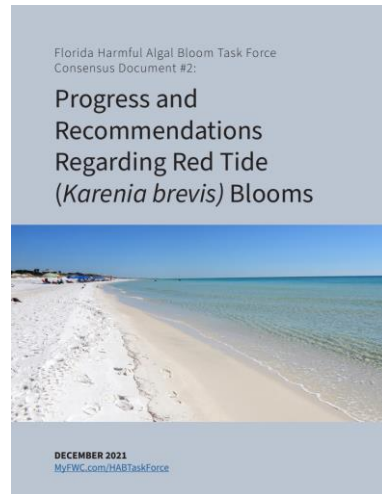
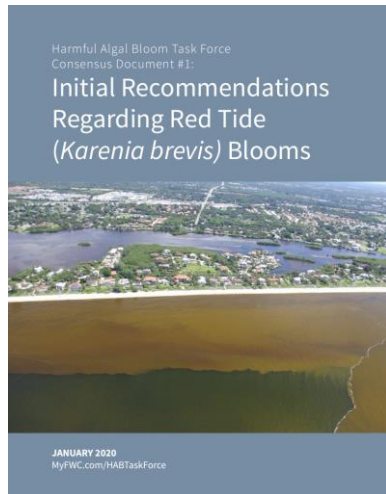


Google Analytics - Red tide short-term tracking and forecast products during 30 days of 2023 Spring Break season (Heil, ECOHAB Annual Report 2023)

R2A Partners: FL Red Tide Task Force, FWRI & Mote Marine Laboratory

→ FL RTTF Long term focal area (Dec 2021):

- ◆ strategic research into the biology and ecology of HAB species
- ◆ 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



In progress:

**South Florida
Interim Integrated
Assessment**

Report to Congress
(HABHRCA 2017)

Florida case study overview

Quality

- Scientists recognized as national and international leaders
- **New and validated technologies (models, HABScope)**
- **32 peer-reviewed publications to date (2019 ECOHAB)**
- Multiple funding sources including CHRP & National Competitive HAB program funding (ECOHAB, MERHAB, PCMHAB) - Competitive merit review by expert panel, relevance, scientific/technical merit (70%)
- **Leveraging FL Red Tide Mitigation & Technology Development Initiative, NSF, FL COMPS, & other funding**

Performance

- Addressing HABHRCA & Action strategy recommendations
- **State agency stakeholders (FWRI) participating on project team**
- **SDI (HABF) collaboration**
- CRP PMs actively participate in project meetings, external communications
- **NCCOS CRP & Project team participation in Florida Red Tide Task Force**
- **Direct collaboration with FWRI, FL RTTF, other Mote Red Tide initiatives**

Relevance

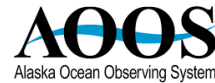
- **Responsive to FL Red Tide Task Force Recommendations**
- **Application of ECOHAB project knowledge for preparedness and response to HABH events following Piney Point disaster and Hurricane Ian**
- **ECOHAB knowledge contributions to South FL Interim Integrated Assessment Report to Congress (HABHRCA)**

Alaska

Shifting focus - HAB impacts to subsistence food safety & security



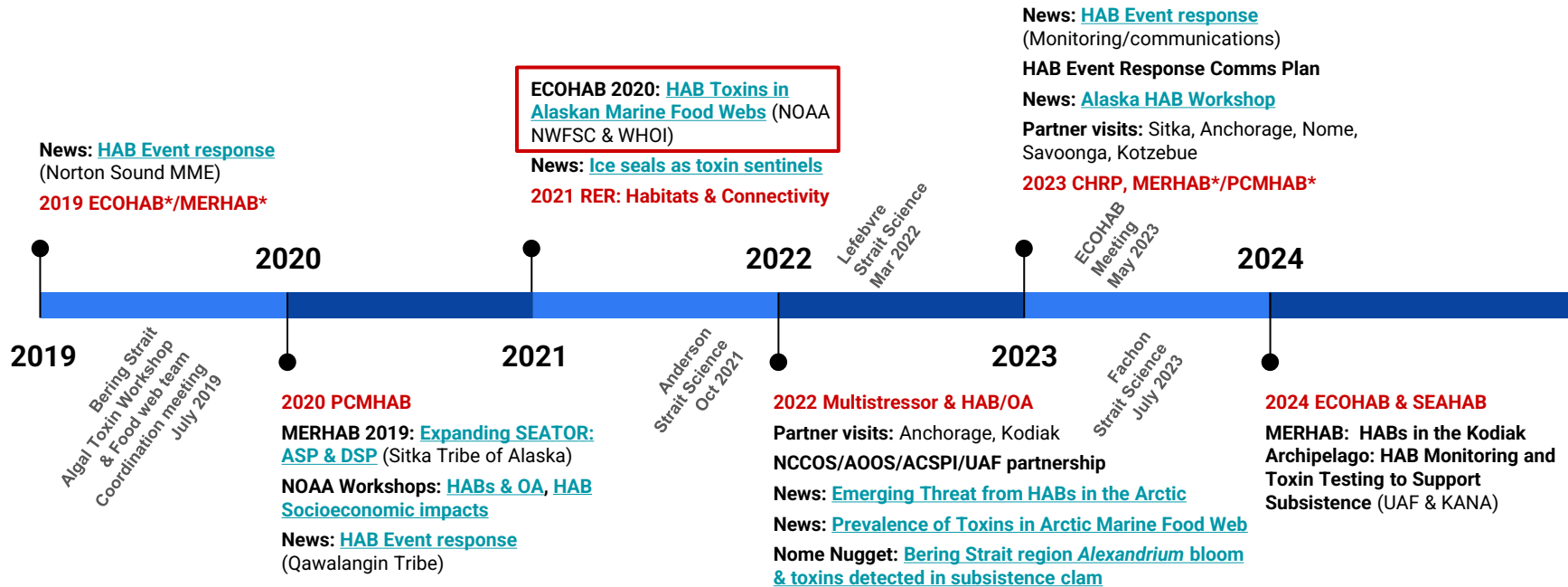
**NORTON SOUND
HEALTH CORPORATION**



NCCOS R2A timeline: Causes & impacts of HABs in Alaska

Pre-2019

- HAB Forecasting efforts in Kasitsna Bay & Kodiak - with APIA & Knik Tribe
- [Phytoplankton Monitoring Network](#) (PMN) partnerships
- NCCOS support for [SEATOR shellfish program](#)
- ECOHAB 2017: [Understanding wintertime shellfish toxicity in the Gulf of Alaska](#) (Eckert, UAF)
- AOS 2017: [Alaska HAB Network](#)
- News: [2018 HAB Event Response](#) (SE Alaska *Pseudo-nitzschia* blooms)



Future

- Continued NCCOS support for HAB impacts to subsistence food safety/security. Meeting community needs (toxin detection)
- Continued engagement with State, Tribal & community partners
- Risk maps? Forecasting? Predicting impacts

R2A: Causes & impacts of HABs in Alaska

WHY? - DESIRED PRODUCT/SERVICE

Understand/predict risks to the environment & human health related to subsistence food safety and security

WHO? - TARGET USER GROUP

Alaska coastal communities
 Subsistence resource users
 Marine mammal resource managers
 —
 R2A - Food safety & security,
 resource management

WHAT? HOW? - CURRENT STATE OF PRODUCT/SERVICE

- Map HAB cell densities & measure toxins
- Define trophic transfer pathways
- Document impacts to marine mammals, fish and seabirds
- Develop models to predict toxins under different bloom scenarios and future events
- Local/regional toxin testing support
- Support subsistence use decisions in Alaska communities

WHO? - NCCOS ORGANIZATION UNITS & KEY PARTNERS

CRP, SDI (HABMR & HABF), and MSE
 —
 NOAA/NWFSC & AFSC, WHOI, USGS, USFWS,
 UAF, AOOS/AHAB, FL/FWRI
 —
 R2A: NSHC, SEATOR, ACSPI, NSB, KANA, ANTHC,
 UAF AK SG, Marine Mammal Commission, Eskimo
 Walrus Commission

Outputs/Outcomes: It's about subsistence



Quilted art, Native Village of Savoonga Community Center

- Subsistence: nutrition, culture, economy
- HAB patterns are changing in Alaska & Arctic waters
- HAB toxins are present and may affect subsistence food safety & security
- T/LEK is not sufficient - the only safe seafoods are tested seafoods
- When, where, and in which foods are HAB toxins present?
- Regional monitoring & toxin testing capacity can reduce human health impacts
- Accurate and appropriate risk communication – Relationships are important!

R2A Partners: UAF/Sea Grant & Norton Sound Health Corporation

- UAF Sea Grant and NSHC OEH conduct regular water sampling near Nome (training by NCCOS/HABMR)
- NSHC OEH analyzes water samples with microscopy for presence/absence of HAB target species
- TBD: Regional toxin testing laboratory
- Goal: Protect human health by providing tools to make informed decisions when harvesting subsistence foods
- 2022-2023 HAB Risk Communications: *Alexandrium* blooms in the Bering Strait region (WHOI, ECOHAB partners)
- Strait Science Seminar Series - UAF NW Campus & AK SG - Communication to stakeholders

Harmful Algal Bloom Toxins



Harmful algal blooms (HABs) occur when tiny algae grow out of control and can produce Paralytic Shellfish toxins that can affect people, marine mammals, seabirds, etc. Saxitoxin is one of these toxins that affect the nervous system, and causes Paralytic Shellfish Poisoning (PSP). HABs and PSP are not new to Alaska and climate change is contributing to these issues. It is important to understand how toxins occur in HABs to try to prevent dangerous health effects from occurring.

How do toxins get into seafood during a Harmful Algal Bloom?

-  1 Certain species of algae can produce naturally occurring toxins known as **domoic acid** and **saxitoxin**.
-  2 During a **harmful algal bloom**, toxin-producing algae grow very quickly and produce these biotoxins.
-  3 Filter feeders like **mussels**, and bottom-dwellers that are like vacuum cleaners to the ocean such as **clams** eat the algae that may contain these biotoxins.
-  4 **Walrus**, **whales**, **seals**, and **crabs** that eat animals/shellfish contaminated with these toxins can potentially also contain the toxins, especially in the contents of the stomach, intestines, and the guts/butter of the crab.
-  5 **Birds**, **marine mammals**, and **humans** can get sick from consuming seafood contaminated with biotoxins. **Paralytic Shellfish Poisoning (PSP)** can occur when people eat clams, crabs, and other seafood contaminated with high levels of saxitoxin. Symptoms of PSP include **diarrhea**, **vomiting** or **nausea**; **tingling** or **numbness** of the **tongue and lips**; **throat irritation** or **difficulty breathing**. If you feel sick or have any of these symptoms after eating shellfish or 'crab butter' **immediately** call the Nurse Call Line at (907) 443-6411 or 844-586-8773.

<https://www.nortonsoundhealth.org>

Alaska case study overview

Quality

- Scientists recognized as national and international leaders
- **9 peer-reviewed publications to date (2020 ECOHAB) - more in progress**
- Multiple funding sources including National Competitive HAB program funding (ECOHAB & MERHAB) - Competitive merit review by expert panel, relevance, scientific/technical merit (70%)
- **Leveraging NPRB, BIA, EPA, NIEHS, NSF OPP and NOAA ARP funding**

Performance

- Addressing HABHRCA & Action strategy recommendations
- **SDI (HABF & HABMR) participation (Kibler, Leighfield, Morton, Fuquay)**
- CRP PMs actively participate in project meetings, external communications
- **Strait Science Seminars**
- **NCCOS HABF leadership: 2023 Alaska HAB Workshop**
- **Summer 2022-2023 HAB Risk Communications**
- **AHAB - Project team/partners active on AHAB SSC**
- **PIs active in US NHC, PICES, ICES, IOC & UN Decade initiatives**

Relevance

- **Imperative to understand HAB risks to subsistence use in Alaska**
- Subsistence use differs by region
- Future implications with climate change
- **Preparedness & response - preventing impacts to human health**
- **Establishing relationships for accurate & appropriate risk communications**

Acknowledgements:



UNIVERSITY
OF
CALIFORNIA



SOUTHERN CALIFORNIA
COASTAL WATER
RESEARCH PROJECT

A PUBLIC AGENCY FOUNDED 1969
Applying next-generation science to aquatic ecosystems management



Florida Fish and Wildlife
Conservation Commission
FWC Fish and Wildlife Research Institute



NORTON SOUND
HEALTH CORPORATION

MAKING INTENTIONAL CONNECTIONS AMONG PARTNERS, PURPOSE, ACTIVITY, AND APPROACH

WHO?

Who are the **partners** and what are their expectations for participation?

WHY?

What is the **purpose** of the partner's participation?

WHAT?

What **activity** are the partners participating in?

HOW?

What **approach** fosters the appropriate level of partner participation?

ALERT

INFORM

INVOLVE

COLLABORATE

CO-CREATE

OUTREACH << Continuum of partner participation >> **ENGAGEMENT**

Source: Carson et al. 2022; <https://doi.org/10.1029/2022csj000001>

Questions



Panel Reflection Time

11:15 – 11:30 PM



LUNCH!

11:30 – 1:00 PM



HAB Observing & Monitoring: *Addressing region-specific stakeholder needs*

Greg Doucette – SDI; HAB Monitoring & Reference Branch

Marc Suddleson – Competitive Research Program

Shelly Tomlinson – SDI; HAB Forecasting Branch

NCCOS HABs & Hypoxia Program Review

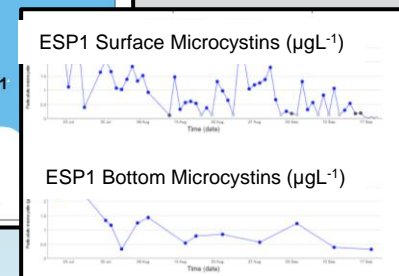
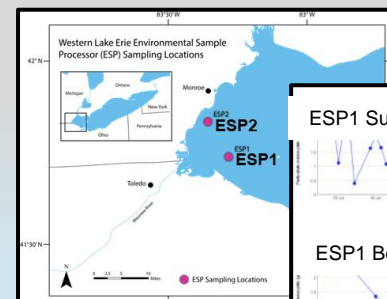
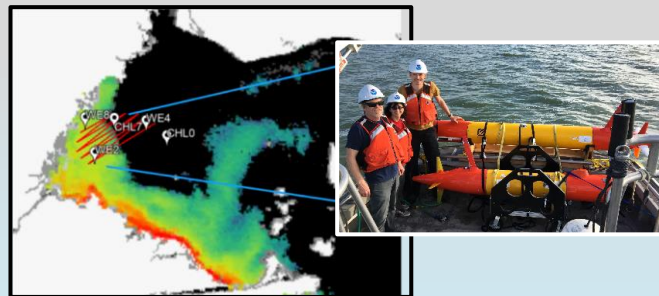
November 28-30, 2023

HAB Observing & Monitoring:

Addressing region-specific stakeholder needs

'TAKE-HOME MESSAGE'

“NCCOS aims to provide sustained, stakeholder-driven observations and accessibility of actionable, region-specific data products/services essential for managing and mitigating HAB impacts.”



National HAB Observing Network (NHABON): a framework & implementation plan for HAB observing & monitoring

NHABON Vision:

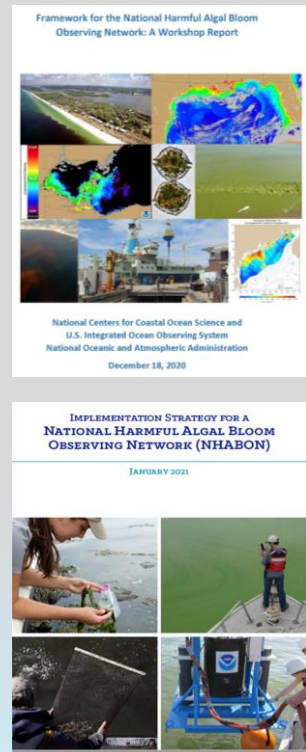
A sustained, national network for regional HAB observing

NHABON Mission:

Delivers sustained HAB observations for: detection, early warning, and forecasting; managing/reducing socioeconomic & environmental impacts

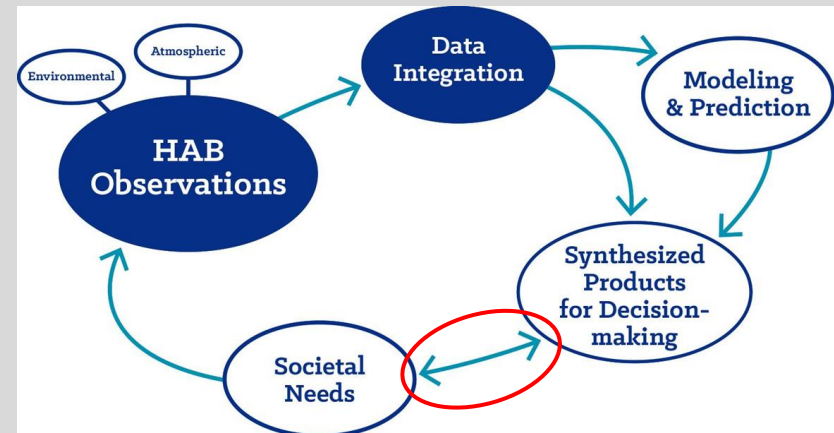
NCCOS & IOOS Lead NOAA's Implementation of NHABON

NHABON Pilot Projects run through all 11 IOOS RAs (3 years; \$9.5M)



National HAB Observing Network (NHABON): a template for regional HAB observing & monitoring

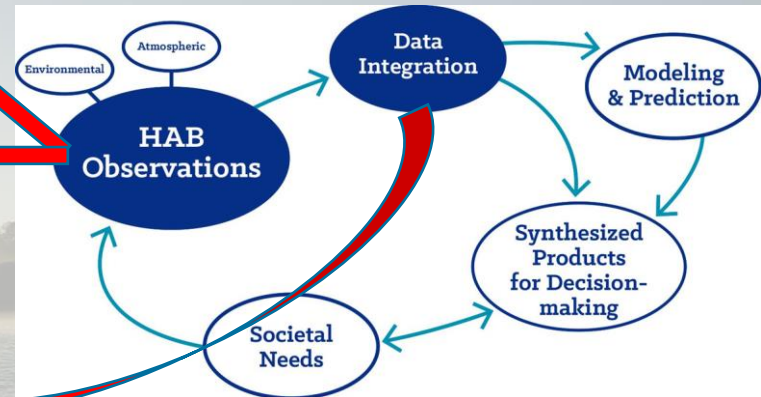
Relies on transition of HAB observing & monitoring data into products & services designed & delivered to address stakeholder needs – coupled with feedback for continuous improvement



As NHABON Community of Practice Steering Committee members, we facilitate continuous engagement with diverse stakeholder groups via topical webinars and create opportunities for feedback via town halls at national meetings.

HAB Observing & Monitoring: *Topics to be Addressed*

- *Uncrewed observing systems*
(Greg Doucette)
- *Satellite monitoring products*
(Shelly Tomlinson)
- *Data management & integration*
(Marc Suddleson)



HAB Sensors & Uncrewed Observing Systems

Sensors for HAB toxin & species detection and their uncrewed deployment platforms are designed to address regionally specific and changing user needs across marine and freshwater systems



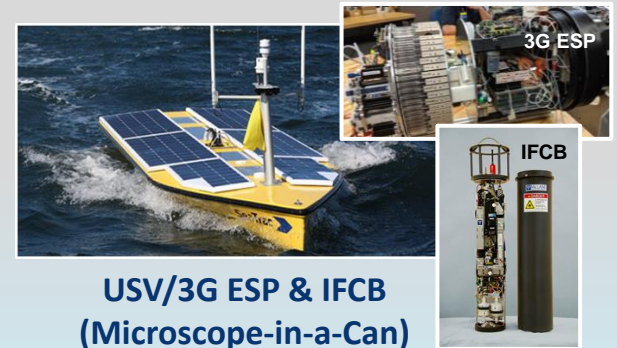
Towable Pontoon Barge (solar)
(IFCB + 2G ESP co-deployed)



2G ESP – Lab-in-a-Can
(fixed position)



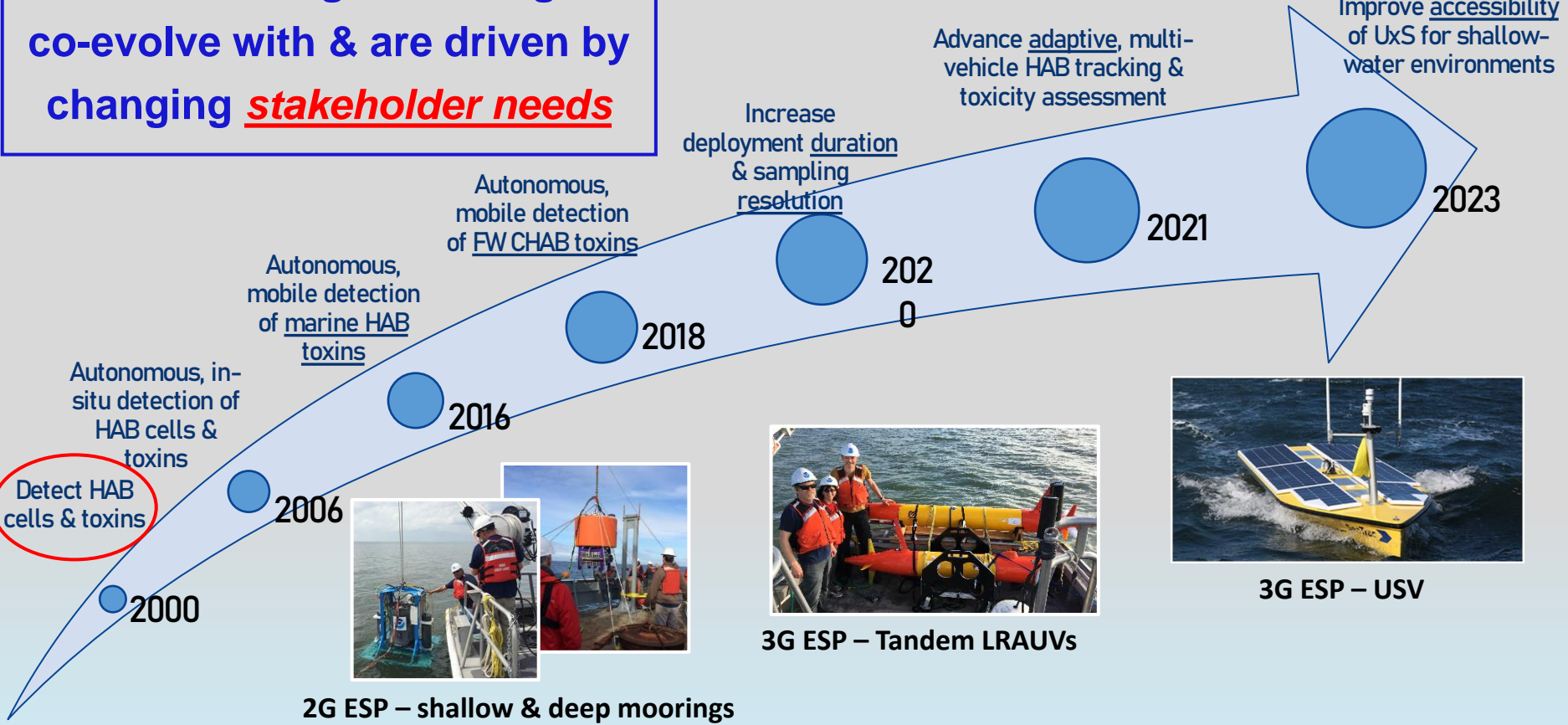
LRAUV/3G ESP: map-track-analyze
(mobile asset)



USV/3G ESP & IFCB
(Microscope-in-a-Can)
(extended offshore duration (solar); shallow draft)

HAB Sensors & Uncrewed Observing Systems

HAB observing technologies co-evolve with & are driven by changing stakeholder needs



HAB Sensors & Uncrewed Observing Systems

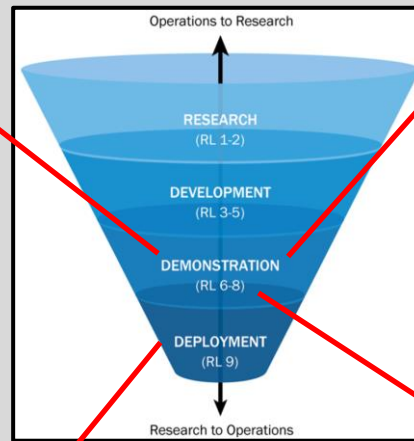
Transitioning HAB Sensors – sensors & deployment platforms can be at different Readiness Levels (RLs), including those NCCOS has helped commercialize



3G ESP/eSPR: RL 7
prototype;
operational
environment



MBARI LRAUV: RL 8
demonstration of final
deliverable (licensed to Saab)



WHOI Towable Barge: RL 7
prototype w/ IFCB or ESP integrated;
operational environment



2G ESP/spESP & IFCB: RL 9
(McLane Res Labs)



SeaTrac USV: RL 9
(SeaTrac)



SeaTrac USV + IFCB or 3G ESP: RL 7
prototype w/ IFCB or ESP integrated;
operational environment



HAB Sensors & Uncrewed Observing Systems

HAB Sensor R&D: guided by close interactions and deep listening with a broad spectrum of partners, stakeholders, and end-users of these tools & technologies



NGOs & PRIVATE INST.



STATE AGENCIES



INTERNAL - NOAA



INDUSTRY



ACADEMIC INST.



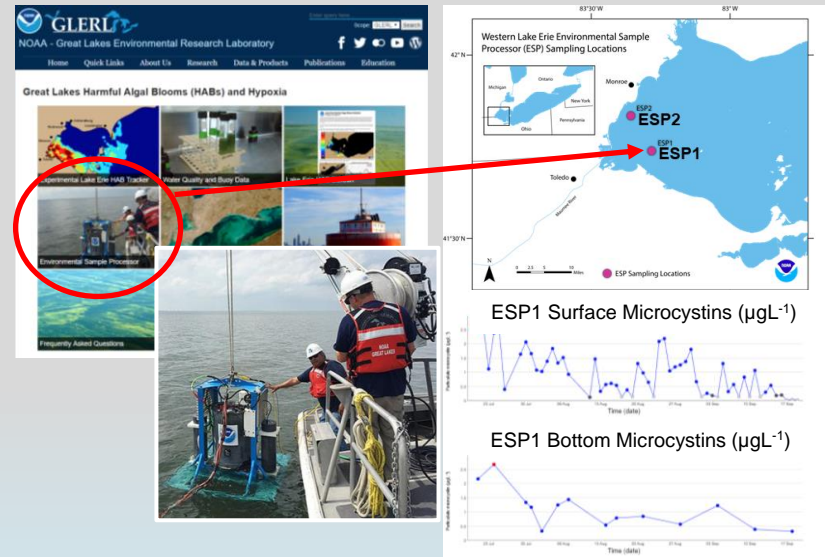
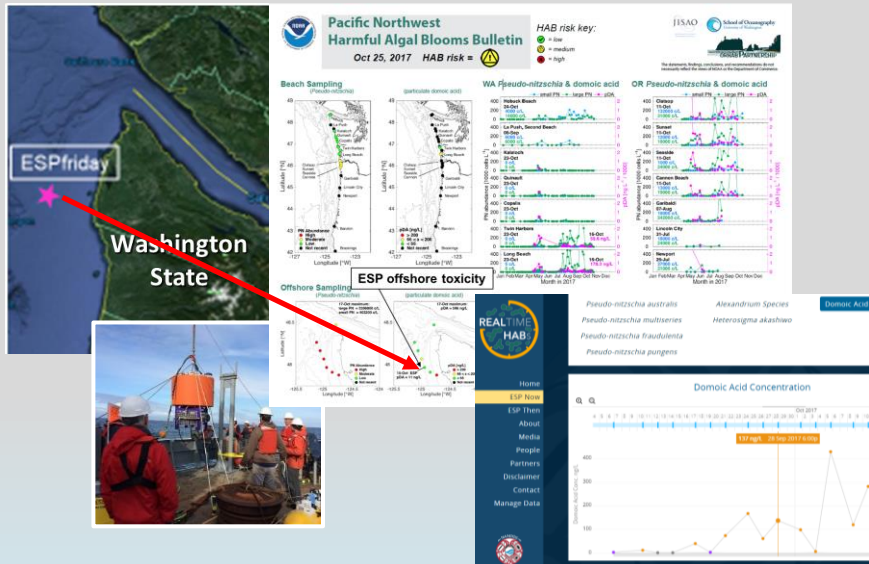
★ All HAB toxin data from a 2G or 3G ESP deployed in US coastal waters or Great Lakes relies on NCCOS-designed toxin sensors & support from NCCOS competitive awards

HAB Sensors & Uncrewed Observing Systems

Service Delivery – Stationary HAB Sentinels: Early warning and dissemination of actionable NRT HAB toxin data to managers as decision support tool (RL 8)

PNW: ESP Toxin Data on NANOOS Real-Time HABs Website and PNW HAB Bulletin

WLE: ESP Toxin Data on GLERL HABs/Hypoxia Website and GLOS HABs EWS



Engagement with stakeholders in PNW and WLE happened ‘early & often’; feedback continues to harmonize product development & service delivery with their needs

HAB Sensors & Uncrewed Observing Systems

Synergistic Technologies: Co-deployment of complementary IFCB & ESP assets for early warning, assessing bloom toxicity, and event response (*RL 7/8*)



cell abundance; spp. ID

+



particulate toxin level

=

Estimate of Bloom Toxicity

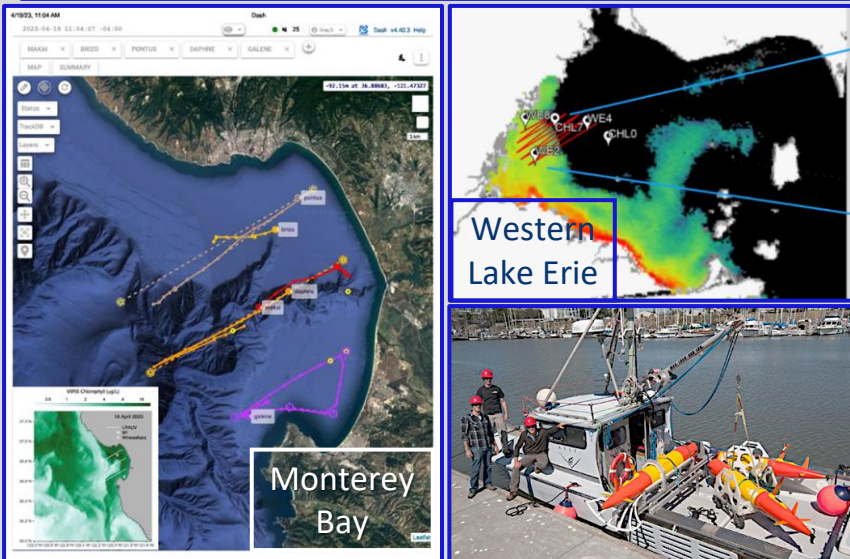


Salsbury Cv, ME
Phyto-ARM
Towable Barge (solar) (IFCB & 2G spESP co-deployed; profiling CTD)

- *addresses needs of aquaculture sector, targeted monitoring programs, event response*
- *ESP toxin analysis triggered by IFCB HAB detection*
- *data disseminated in NRT via HABON-NE and HABhub (in progress)*
- *enables efficient redistribution of sensors according to service delivery requirements*

HAB Sensors & Uncrewed Observing Systems

Mobility Matters! LRAUV/3G ESP addresses stakeholder need for easily deployed mobile asset for HAB mapping, tracking, and toxicity/biomass assessment (**RL 7/8**)



- *24x7 offshore ops; deploy from small boat*
- *cost-effective alternative to ship sampling*
- *wide coverage w/ high spatial/temporal res.*
- *complements satellite & aircraft RS*
- *delivers NRT reporting of in-situ HAB data*
- *signed transition plan in place via ORTA; ultimately integrate LRAUV w/ NOAA UxS fleet*

Multi-vehicle LRAUV/3G ESP deployments for adaptive, coordinated HAB monitoring

HAB Sensors & Uncrewed Observing Systems

HAB Sensors: ‘TOP LINE MESSAGE’

Decisions on management actions to mitigate HAB impacts require sustained, timely, actionable observing data to assess regional risks associated with toxicity and biomass

‘RECOMMENDATION’

NCCOS support for HAB sensor development is key to enabling the stakeholder-driven, adaptive R&D required to maintain high quality performance and long-term relevance

‘THE PATH FORWARD’

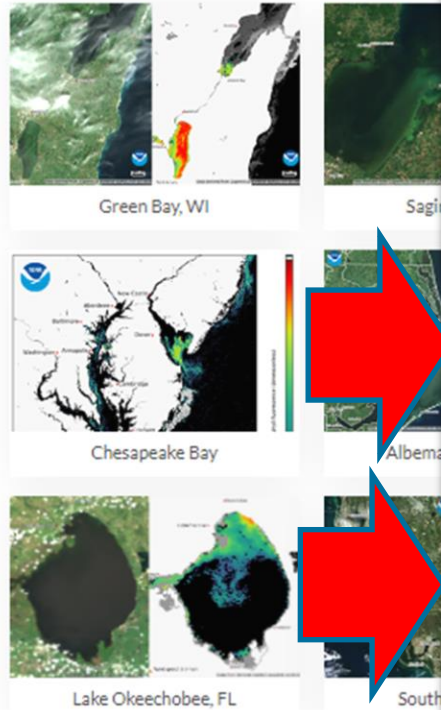
Enhance dialog with regional stakeholders to ensure HAB sensor R&D and capabilities remain relevant by identifying new gaps and harmonizing technologies with applications



Satellite-based Harmful Algal Bloom Monitoring

HAB Monitoring Products

NCCOS developed the Algal Bloom Monitoring System to routinely deliver near real-time products for use in locating, monitoring and quantifying algal blooms in coastal and lake regions of the US. This application delivers a suite of bloom detection products in the form of geographic based images. At this time products are available for selected regions. New products are being evaluated, and new regions are being considered; as they are proven useful, they will be made available through this system. [See more](#)



Providing 300 m Sentinel-3 (OLCI) satellite for monitoring since 2016 and added experimental Sentinel-2 (MSI) imagery during COVID in some

Start - + < > Zoom 10/28/2023

Need Help? Contact the Help Desk:
Email | (301) 683-3335

2022-09-14 (257)
14:48:00

Sentinel-3AB/OLCI_nccos
Chesapeake Bay
Relative Fluorescence
PNG TIFF

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Information Quality • FOIA • Disclaimer
USA.gov • Department of Commerce

Cyanobacteria Index (CICyano) for Lake Okeechobee. The algal bloom is present but cloud cover or winds above 9.0 mph prevent determining an area (previous area from Oct 23 was 120 square miles). Winds above 4.0 mph may begin mixing the bloom and clouds may obscure it, leading to an underestimate of the area. Moderate and low concentrations may not be obvious to the eye. Average wind for preceding 3 hours of satellite observation from South Florida Water Management District station LZ46.



Cyanobacteria Assessment Network (CyAN)

Multi-agency project EPA, NOAA, USGS, NASA

GOAL: Support the environmental management and public use of U.S. lakes by detecting and quantifying algal blooms and related water quality indicators using satellite data records.

Approach

Remote Sensing

Uniform and systematic approach for identifying cyanobacteria blooms.
Strategy for evaluation and refinement of algorithms across platforms.

Information Distribution

Leveraged EPA regions to bring the technology, training and tools to EPA, states and tribal partners. Provide notifications and decision support

Economics

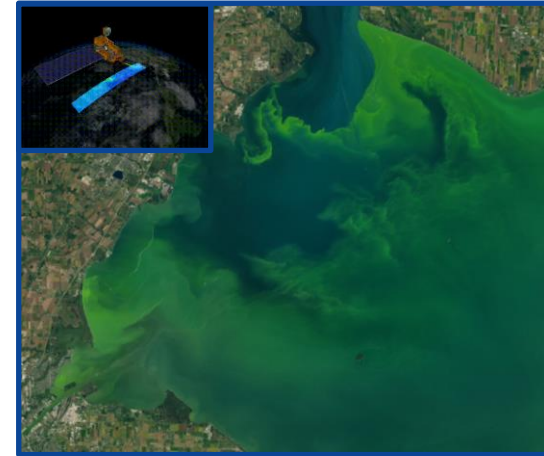
Behavioral responses and economic value of the early warning system.

Environment

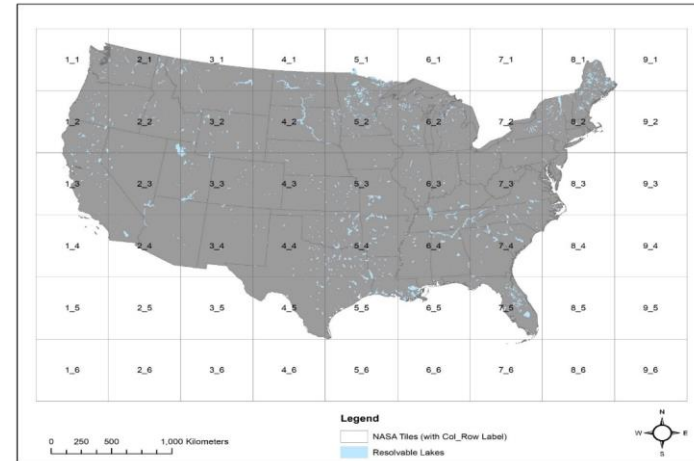
Identify landscape linkages causes of chlorophyll a and cyanobacteria.

Health

Exposure and human health effects in drinking and recreational waters.



Real-time delivery of tools and products

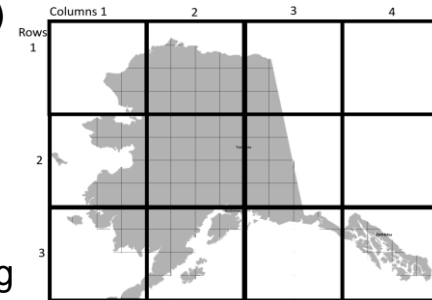


<https://www.epa.gov/water-research/cyanobacteria-assessment-network-mobile-application-cyan-app>

CyAN App

- easily share data and information with large numbers of people
- focus on individual lakes, current conditions and historic
- compare lakes of interest

- Contiguous US (CONUS) tiles available for US and Alaska
- MERIS (2002-2012)
- OLCI (2016-)
- Full resolution (300 m)
- Provided tools for working with imagery and training through EPA regions



https://oceandata.sci.gsfc.nasa.gov/api/cyan_file_search/

CyAN App Love



Aaron Borisenko, State of Oregon Department of Environmental Quality:

“... using CyAN app as an early warning system.”

Bart Johnsen-Harris, Environment America:

“...CyAN has proved to be a uniquely helpful tool!”

Angela Shambaugh, Vermont Department of Environmental Conservation:

“... visualize that patchiness and provides additional context...”

Lenard Long, Lake Cascade Citizen Scientist Monitoring Group:

“...enhance the community's ability to rapidly respond to and manage the growing threat posed by toxic algae...the CyAN app helps us do that....has been extremely useful....”

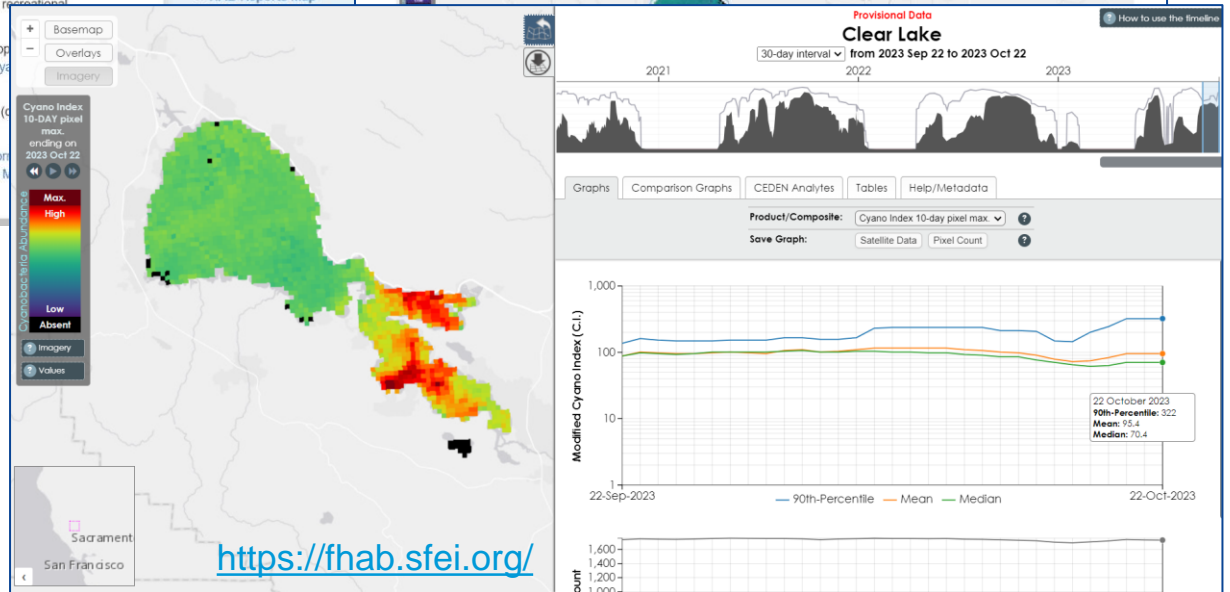
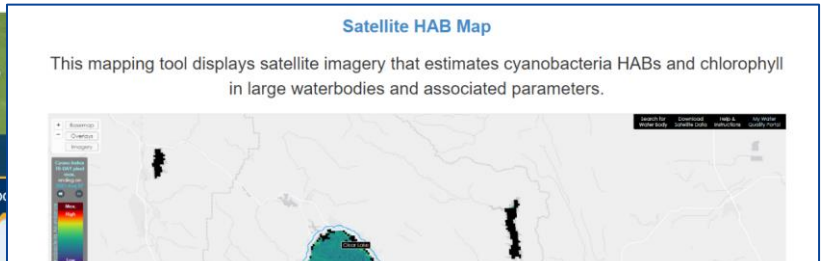
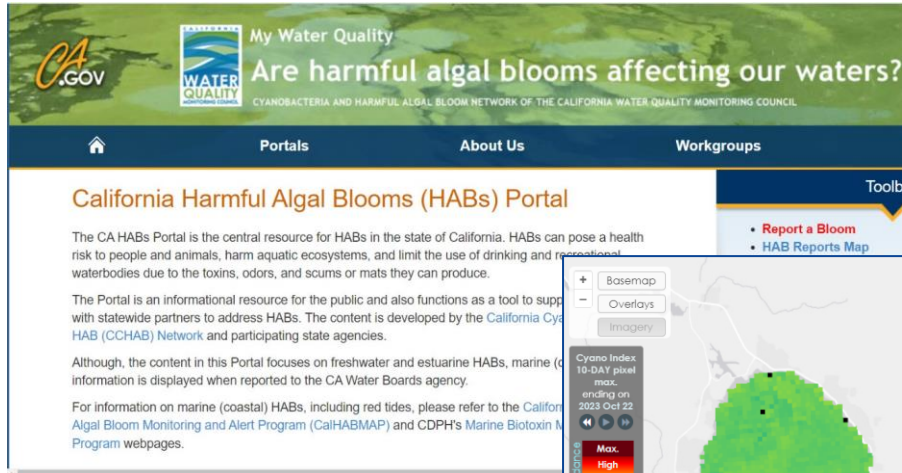
Benjamin Holcomb, Utah Department of Water Quality:

“... allows UDWQ to better target field sampling and more efficiently use our limited resources to protect public health...”



American Possibilities: A White House Demo Day

California Cyanobacteria and HAB Network Website



<https://mywaterquality.ca.gov/habs/>

CA Water Board in collaboration with San Francisco Estuary Institute

Contacts:

randyt@sfei.org

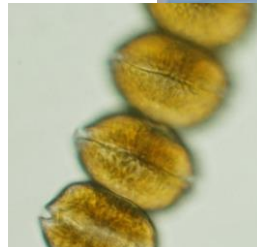
Marisa.VanDyke@waterboards.ca.gov

[v](#)

<https://fhhab.sfei.org/>

Chesapeake Bay – Aquaculture, Water Quality

Clam and oyster farming is a booming, multi-million dollar industry in Chesapeake Bay



A. monilatum



M. polykrikoides

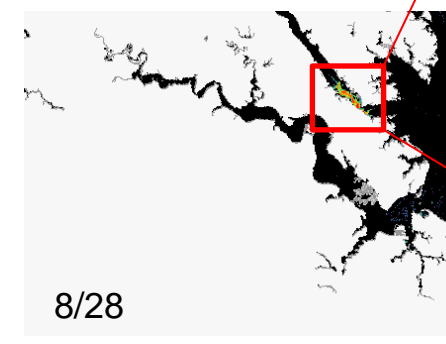
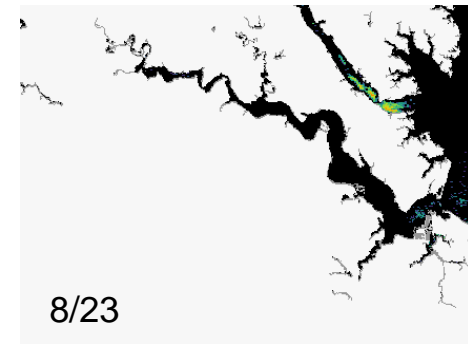
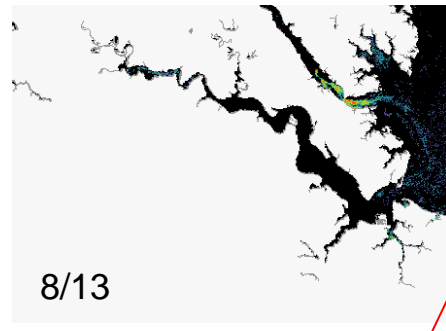
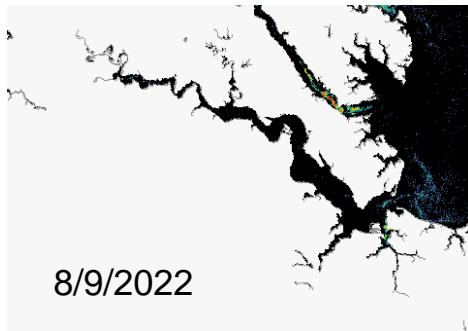
York River *M. polykrikoides*
Photo Credit: Wolfgang Vogelbein (VIMS)



Pictures courtesy of Kim Reece (VIMS), Rusty McKay (MDE) and Jen Wolny (FDA)

NCCOS Assists Response to HAB in the Lower Chesapeake Bay

Sentinel 3 Relative Fluorescence algorithm (RBD) from EUMETSAT processed at NCCOS, 300 m every day



Sentinel 2 provides 20 m imagery every 5 days



False color image from EO Browser at European Space Agency (ESA)

<https://apps.sentinel-hub.com/eo-browser/>

*Resulted in NCCOS HAB Event Response funds to support additional sampling

Stakeholder engagement in Northeast and Mid-Atlantic

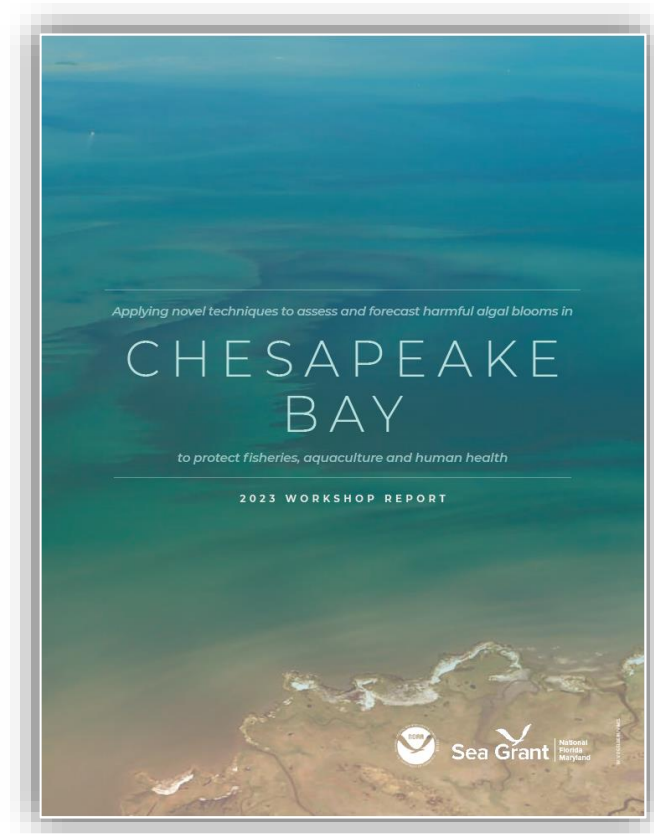
- 1) Joint NCCOS/SeaGrant workshop in Jan 2023 for Chesapeake Bay (Follow up to MD SeaGrant workshop in 2014)

Goal: Applying novel techniques to assess and forecast HABs in Chesapeake Bay to protect fisheries, aquaculture and human health

Outcomes:

- Two needs assessments and Final Report
- New Industry contacts and engagement (recreational fishing, aquaculture, state resource managers)
- Introduction of NCCOS Phytoplankton Monitoring Network (PMN) and subsequent training in Chesapeake Bay

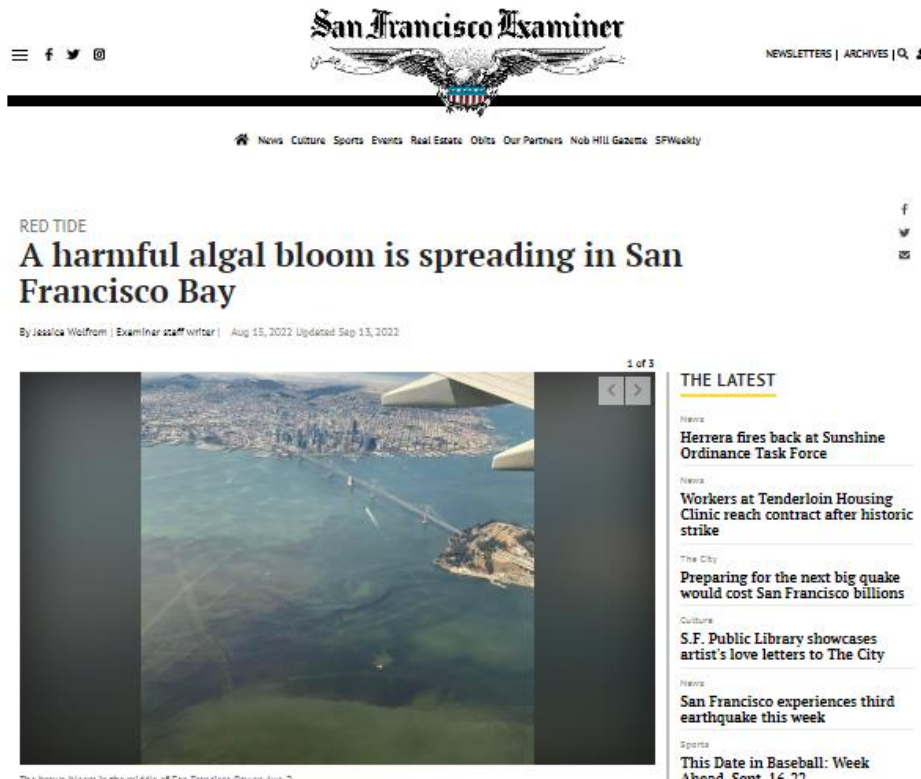
- 2) Additional engagement with Aquaculture Industry through:
NOAA CoastWatch
NMFS Office of Aquaculture
SeaGrant Aquaculture Extension agents in the Northeast



https://www.flseagrant.org/wpcontent/uploads/2023/05/CB_HABWorkshopReport_Final050423.pdf

San Francisco

Heterosigma akashiwo bloom



Atypical *Heterosigma akashiwo* bloom in San Francisco Bay causes massive fish kills (rays, various fish, bass, sturgeon) in mid-August 2022, impacting 9 counties. Last bloom was more than 10 years ago.

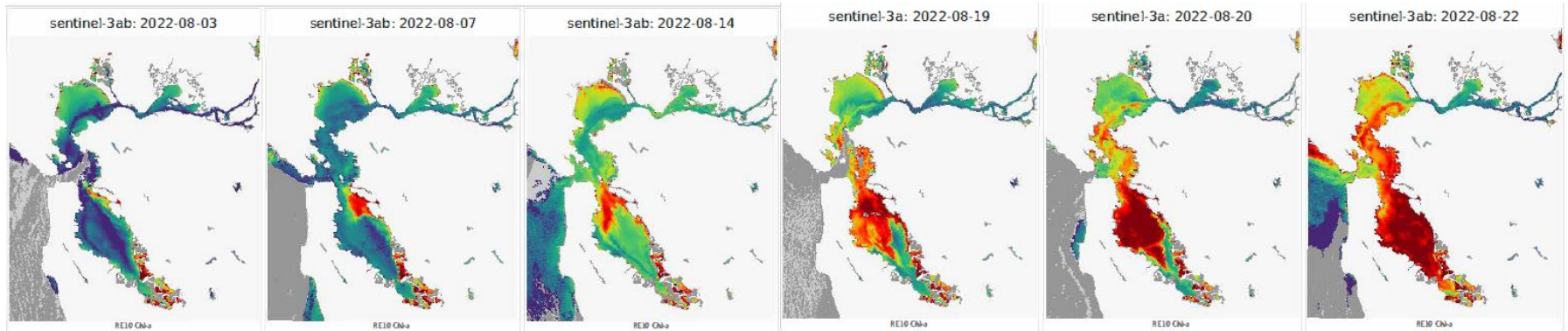
NOAA processed several algorithms (chl a, high biomass fluorescence) to help delineate the bloom.

A National monitoring system would have provided improved guidance for sampling efforts and validation of bloom extent and movement


*Resulted in NCCOS HAB Event Response funds to support additional sampling

Relative chl *a* levels from Sentinel-3 satellite imagery

“Had we not had remote sensing imagery, we definitely would not have realized the bloom had expanded after our 8/17 sampling and probably would have missed a key moment in the blooms trajectory”, Keith Bouma-Gregson, USGS California Water Science Center



Prompted Rapid Development of CA Waterboard Fact Sheet


FAQ

Frequently Asked Questions about the San Francisco Bay Harmful Algal Bloom

First reported in late July, a specific kind of harmful algal bloom known as a red tide has spread throughout much of the San Francisco Bay, alarming onlookers who've seen the heavy toll it has already taken on aquatic life. While teams of scientists continue to investigate the cause, many are left to wonder about the ongoing impact. Here are answers to some of the most common questions we are getting.

Why is the water in San Francisco Bay reddish brown?

The San Francisco Bay is experiencing a type of [harmful algal bloom](#) (HAB) known as a red tide. The species associated with this bloom, *Heterosigma akashiwo*, can cause water to take on a reddish-brown color. The red tide was first observed near Alameda. This bloom now extends throughout the open-bay regions of the South Bay, the Central Bay and into San Pablo Bay.

Is this normal?

Red tides are known to occur off the coast of California, usually from early spring through late summer. They can be bioluminescent at night, often looking like glowing waves from the beach. They can last days to months and it is difficult to predict how long they will last due to sunlight, temperature, tidal flow, stratified water columns and nutrients. Red tides are often attributed to depletion of oxygen in the water that marine life needs to survive. It is not as common for red tides to enter the estuarine environment like the one in the San Francisco Bay.

Is it safe eat the shellfish or swim?

This type of red tide is not known to cause human illness, but we always encourage people and pets to avoid contact with any discolored water that may be caused by the red tide and to practice [healthy water habits](#).


The San Francisco Bay Regional Water Quality Control Board has worked with various agencies, including the City of Oakland, Alameda County, San Mateo County and East Bay Regional Park District to post caution [advisory signs](#) near affected waters (e.g., Lake Merritt, the Oakland Estuary, Coyote Point, and Crown Beach), so the public knows to avoid contact with the discolored water caused by the red tide. We encourage other water-based facilities that observe discolored water to post similar signs to keep the public informed.

On May 1, the Department of Public Health (CDPH) issued a prohibition against harvesting for eating mussels along the entire California coast, including bays. The prohibition is still in place. For updates or questions regarding the prohibition, contact the [CDPH marine biotoxin monitoring program](#) or redtide@cdph.ca.gov.

Why are there so many dead fish?

We are getting reports of fish deaths across San Francisco Bay that appear to be linked to the red tide, including sturgeon, striped bass, sharks, bat rays, smelt and anchovy. We are coordinating with the Office of Environmental Health Hazard Assessment (OEHHA), the California Department of Public Health (CDPH), and the California Department of Fish and Wildlife (CDFW) to investigate the potential link between this bloom and fish deaths. Algal blooms, such as this one, can create toxins that are detrimental to fish and other animals, and as algal matter dies off during and after a bloom, the decomposition process uses up oxygen in the surrounding water that can cause organisms and fish to suffocate.

At Lake Merritt, which is connected to San Francisco Bay, reports suggest as many as 10,000 fish died in late August. On Aug. 29, San Francisco Bay Regional Water Board staff conducted a field investigation at Lake Merritt, where very low dissolved oxygen levels were measured in the water. Water samples were collected for identification of algal species and toxins. Updates to this sampling event will be posted on the [HAB web msp](#).


Fact Sheet

September 2, 2022

Satellite Imagery of Harmful Algal Bloom (HAB) in San Francisco Bay and Estuary

Overview

The San Francisco Bay and estuary is currently experiencing a [harmful algal bloom](#) (HAB), more specifically a red tide. The species associated with this bloom, *Heterosigma akashiwo*, is one of several marine species that can cause water to appear a reddish-brown color. These red tides are harmful to marine animals, including fish. The Water Boards have received numerous reports of fish kills across the San Francisco Bay that appear to be linked to the red tide. This red tide can cause an allergic reaction or irritation of the eyes, skin, or respiratory system. We recommend people and pets to avoid contact with any discolored water that may be caused by the red tide and to practice [healthy water habits](#).

The Freshwater and Estuarine HAB (FHAB) Program under the CA Water Boards has been collaborating with federal, state, and local agencies to respond to this extensive HAB, particularly to coordinate recreational health postings and tracking. Federal agencies are providing processed satellite imagery that shows this HAB event to support tracking of the bloom's progression and density so that field investigations can be better directed.

Satellite imagery can help track HABs:

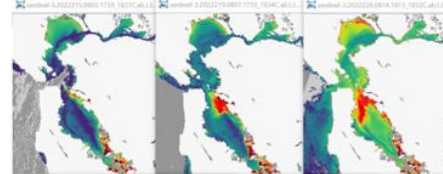
We use processed satellite imagery to track HABs with an indicator called chlorophyll-*a*. These algal blooms consist of algae and bacteria cells that contain photosynthetic pigments, one of which is chlorophyll-*a*. This pigment is detected by instruments on satellites and complex calculations translate what the instrument is detecting to estimate the amount of chlorophyll-*a*. Chlorophyll-*a* can also be measured on the ground by collecting water samples for analysis.

Maps are used to display the satellite imagery. The figures below display snap shots in time on days in August when the satellite crossed overhead. The density of the indicator detected at the water surface is represented on a scale of cool to warm colors, the warmest colors represent the highest densities.

Satellite imagery summary from August 2022:

Daily snapshots of the satellite imagery are presented in Figure 1 showing the spatial development of the bloom across the bay. Estimated density of the chlorophyll indicator is displayed in the scale bar. Based on this data the bloom peaked from August 20-26 and appears to be dissipating. Experts have cautioned that if the conditions that promoted growth of the bloom do not decrease the bloom may rebound, the heat wave in early September may support bloom growth and decrease dissolved oxygen in the water needed by fish.

Figure 1: Satellite imagery maps of SF Bay from August 3-30, 2022.

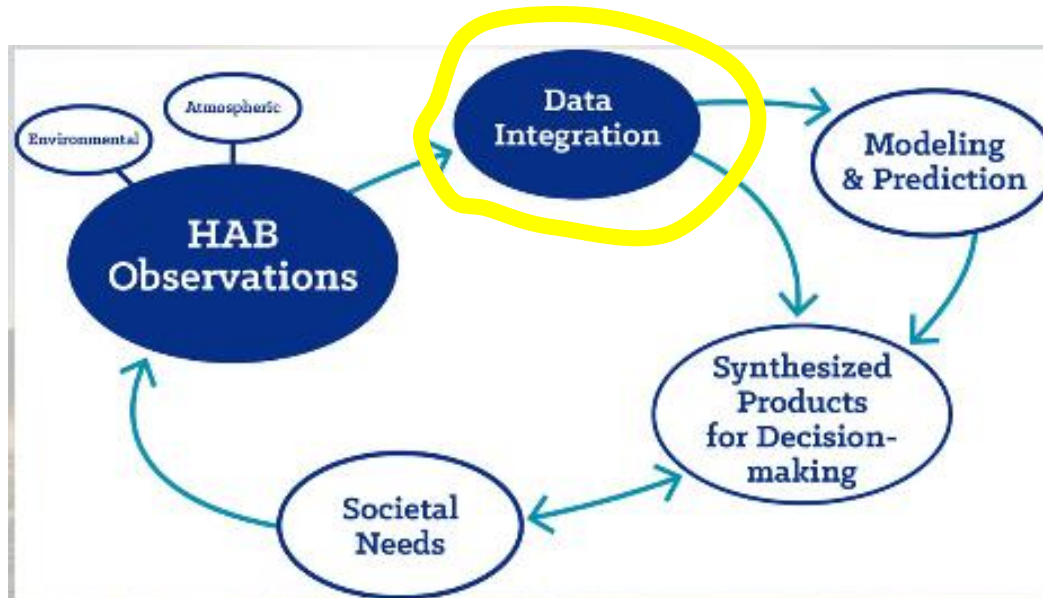


E. JOAQUIN ERQUIVEL, OWNER | EILEEN SOROCK, EXECUTIVE DIRECTOR

1001 J Street, Sacramento, CA 95814 | Mailing Address: P.O. Box 100, Sacramento, CA 95812-0100 | www.waterboards.ca.gov

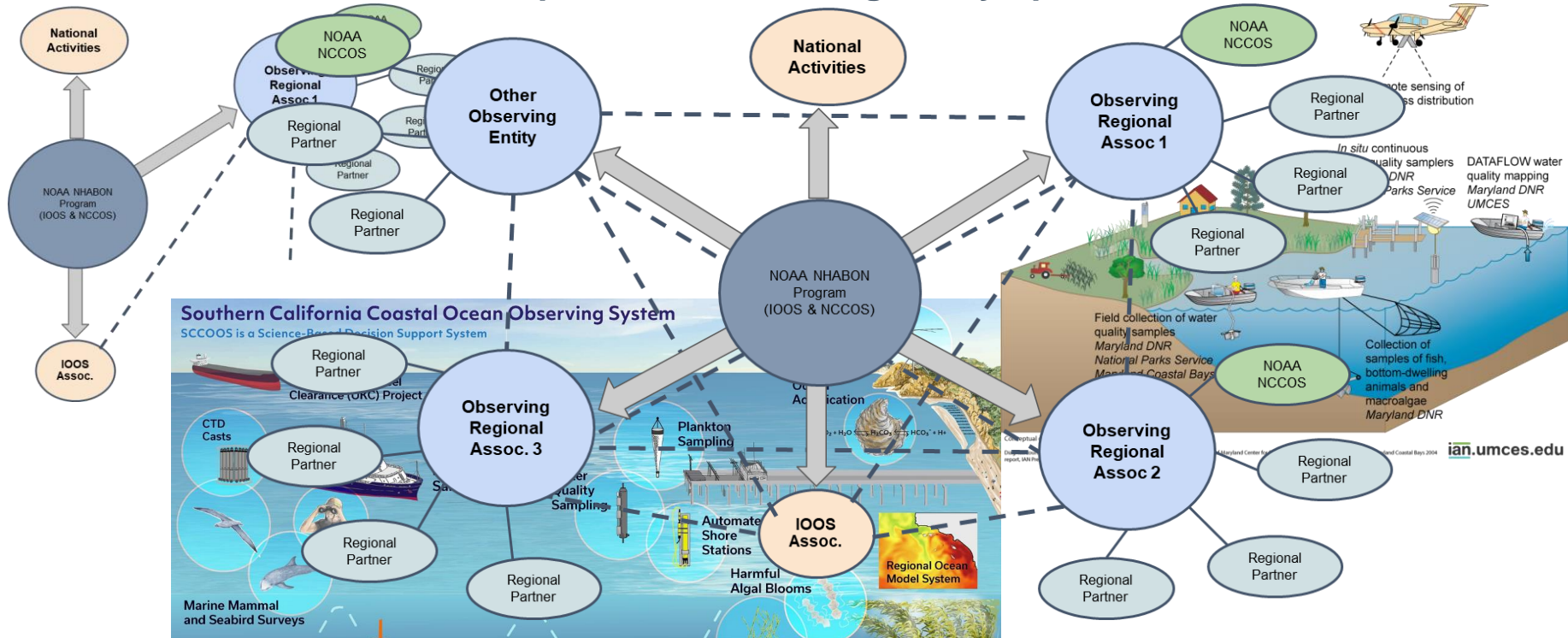
Observing and Monitoring: Data Integration

Top Line 1 Coordination and integration of HAB data at regional and national levels harmonizes accessibility and interoperability



Observing and Monitoring: Data Integration

Top Line 2 Flexibility to integrate sensor, satellite, toxicity, and ancillary data sourced from NOAA and partners to meet regionally-specific stakeholder needs

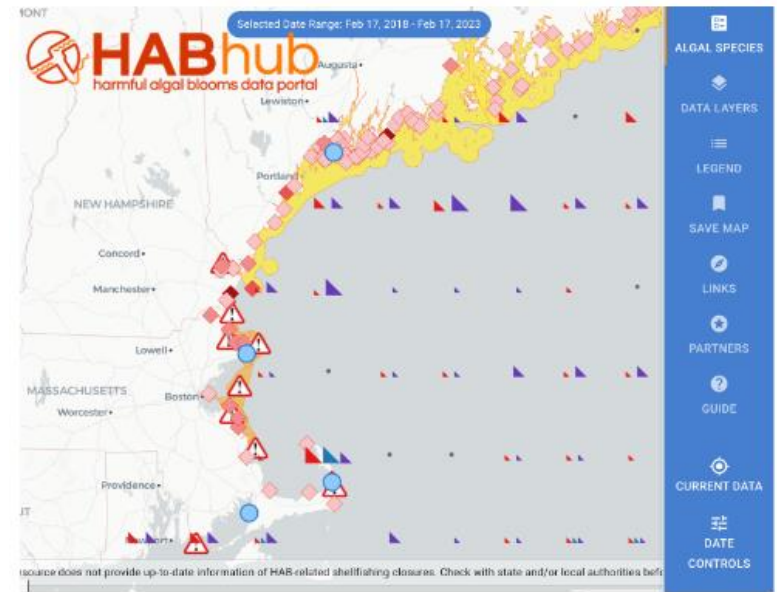


Regional Data Integration – WHOI HABHub

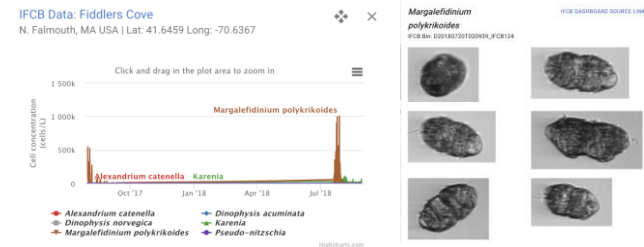
a [web server](#) supporting data integration, visualization and product sharing

Development Goals

- Best possible situational awareness
 - automated data ingestion, standardized plots and products
- Serve [diverse audiences](#)
 - fishermen, aquaculturists, resource managers, scientists, K-12 educators, public
- Open source design
 - accessible, changeable architecture allows transfer to other HAB observing networks.
- Data attribution to facilitate reuse and sharing
 - Provide direct access to data sources (provenance)
 - Linked SOP documentation (IFCB, ESP, etc.)



WHOI HABHub data prototype data layers include toxin monitoring data, shellfish closures, and Imaging Flowcytobot sensor data.

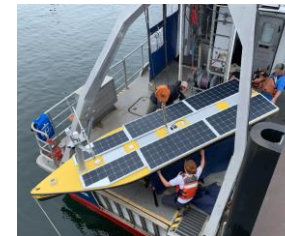
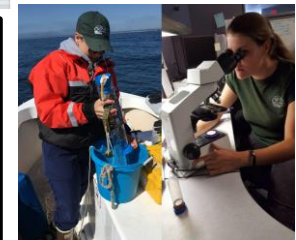
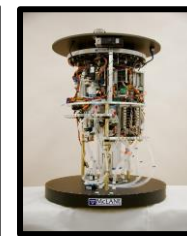
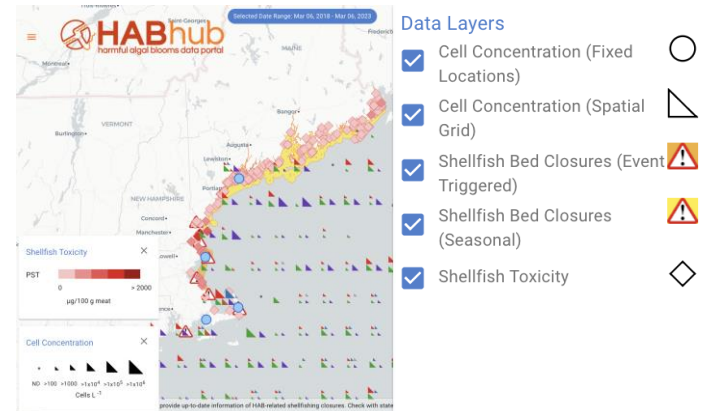


Credit: Richlen, Brosnahan (WHOI PIs)

Regional Data Integration – WHOI HABHub

Challenges Overcome:

- How to show multiple species/toxins simultaneously?
- Consider different measurement sources (sensors, microscopes) and different partners (state, grower, academic, NOAA)
- Provide direct hooks to inspect primary sources of data, export of data and visualizations by end users
- Facilitate retrospective comparisons – how are current conditions similar or different than the past?
- Institutional barriers to transferring data between [partners](#) (state, NOAA, other feds, etc).



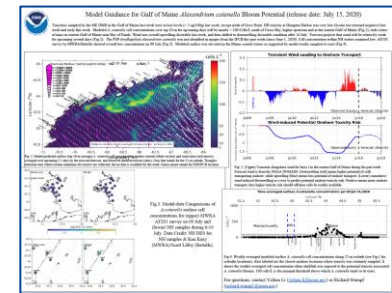
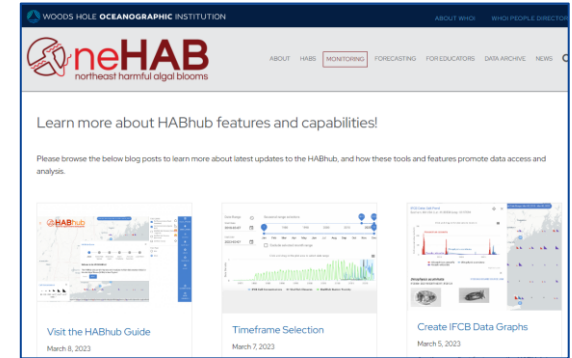
Credit: Richlen, Brosnahan (WHOI PIs)

Regional Data Integration – WHOI HABHub

Responding to Stakeholder Needs

Objective: Develop HABhub for broad adoption by management agencies and other stakeholders.

- Annual meetings with Gulf of Maine Stakeholders and NOAA
- Meeting annually since 2002
 - (states, growers, academics, & NCCOS)
- Exchange updates and get stakeholder feedback
- HABhub Features Guides, Tutorials
- NERACOOS - RA Director (co-PI) exploring transition of WHOI data management capacity to NERACOOS to support an operational HAB observing network
- NCCOS - Li & Stumpf (co-PIs) working to visualize forecast products in HABhub and display model and sensor outputs.
- WHOI Anderson & NCCOS Doucette (co-PIs) to add shellfish toxicity predictions from ESP data to HABhub



Credit: Richlen, Brosnahan (WHOI PI)

Toward Data Infrastructure for NHABON

California HAB Data Assembly Center

- Responding to [Stakeholder Needs](#) ID in 2019 West Coast COMT workshop, via NCCOS project TAC, and NHABON Community of Practice.
- Leverage California IFCB investments to harness the power of networked imaging HAB sensors to meet regional stakeholder needs
- [HABDAC](#) is a centralized hub for IFCB HAB data, ancillary observations, and technologies for IFCB image classification\ annotation, and user support.
- Envision expansion a national scale to promote harmonized data feeds and generation of management-relevant products

CA Imaging FlowCytobot (IFCB) Network

12 total IFCBs

- 6 pier-based
- 2 offshore moorings
- 4 shipboard cruises

<https://ifcb.caloos.org>

Harmful Algal Bloom Data Assembly Center (HABDAC)

Harmful algal blooms (HABs) represent a major coastal hazard that can lead to closures of marine fisheries, disease and other effects on marine ecosystem structure and function, and direct harm to coastal community health and economies. Such phenomena have caused substantial economic losses to fisheries and tourism in recent years on the U.S. East and West Coasts and Gulf of Mexico. In the last decade, the ocean science community has developed several novel sensors and methods for monitoring and predicting a diversity of HAB events. These include the Imaging FlowCytobot (IFCB), the Environmental Sample Processor (ESP), and various biophysical modeling systems optimized for HAB prediction.

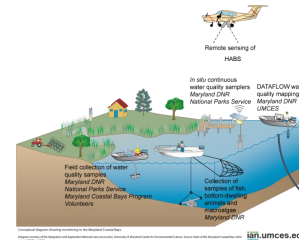
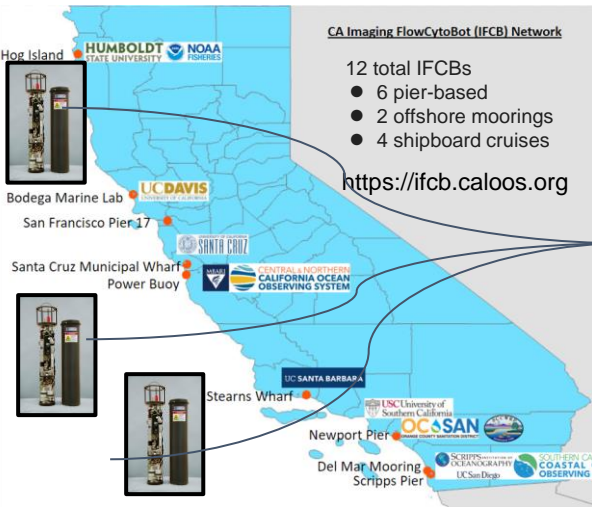
The HABDAC data portal provides a centralized location for existing HAB data products including near real-time imagery, sampling feeds, and access to HAB modeling results.

Explore map Catalog

C-HARM Model Real-time Sensors California IFCB locations Gulf of Maine IFCB locations

Credit: NCCOS | Pls - Anderson (Scripps, UCSD) & Boehnke (Axiom)

Toward Data Infrastructure for NHABON

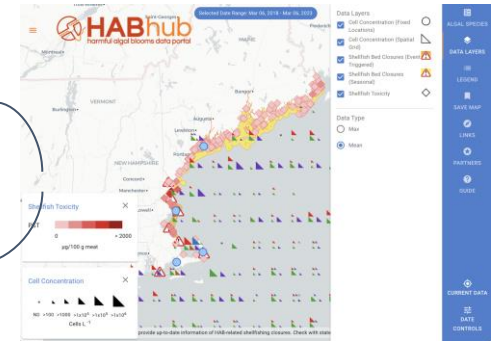


Harmful Algal Bloom Data Assembly Center (HABDAC)

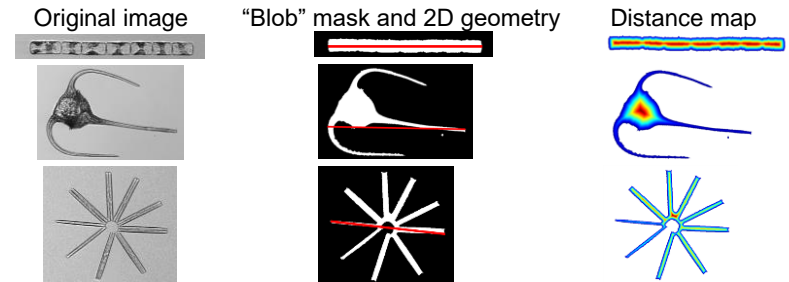
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The HABDAC data portal provides a centralized location for existing HAB data products including near real-time imagery, sampling feeds, and access to HAB modeling results.

Explore map | Catalog



Automated image processing for trait estimation



MATLAB development environment → Python operational environment

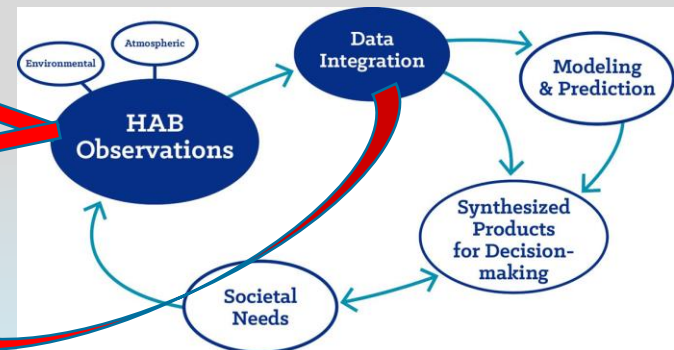
Credit: Pls: Anderson Scripps/UCSD/SCCOOS; Bochenek, Axiom

HAB Observing & Monitoring: Summary & Wrap-Up

'TAKE-HOME MESSAGE'

“NCCOS aims to provide sustained, stakeholder-driven observations and accessibility of actionable, region-specific data products/services essential for managing and mitigating HAB impacts.”

- *Uncrewed observing systems*
- *Satellite monitoring products*
- *Data management & integration*



HAB Observing & Monitoring: Summary & Wrap-Up

‘RECOMMENDATIONS’

- NCCOS support for HAB sensor development is key to enabling the stakeholder-driven, adaptive R&D required to maintain high-quality performance and long-term relevance.
- NCCOS supports development of nationally relevant satellite products for algal bloom monitoring/ assessment, informed via close engagement with stakeholders on products and including integration of next generation, higher resolution satellite missions.
- NCCOS, IOOS, and RAs continue to assess piloted HAB data coordination/ integration systems (e.g. HABhub and HABDAC) to harmonize data accessibility/ interoperability and provide flexibility to ingest diverse HAB data to meet regional stakeholder needs.

HAB Observing & Monitoring: *Sustained Service Delivery*

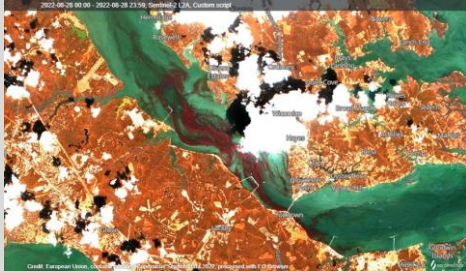
Continuous engagement with our regional stakeholders is the foundation

for enabling sustained delivery of services required to address their diverse and changing needs...

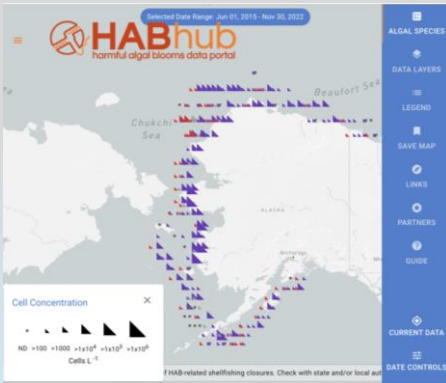
NCCOS successfully transitions our world-class R&D to operations, applications, and commercial products to meet our customers' needs!



Credit: NOAA Water Initiative 2020



Thank you for your attention!
Questions...



15 minute Break!

Return by 3:00PM



NCCOS HAB & Hypoxia Forecasts

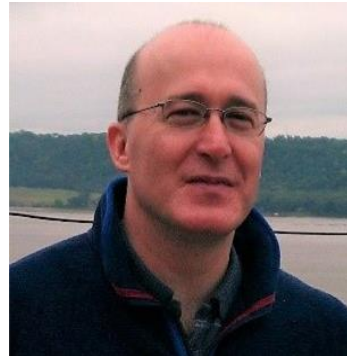
Regional forecasts within a national framework

Session Co-Leads

Alex Hounshell, Ph.D. David Scheurer, Ph.D.



**HAB Forecasting
Branch**



**Competitive
Research Program**

Case Study Presenters

Richard Stumpf, Ph.D. Quay Dortch, Ph.D.

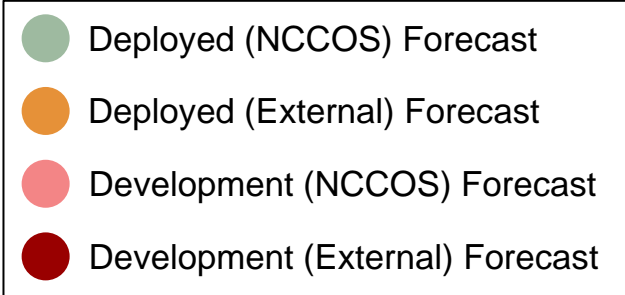


**HAB Forecasting
Branch**



**Competitive
Research Program**

Regional Forecasts, National Coverage



- Multiple product lines & capabilities
- Sustained delivery based on HAB & stakeholder needs
- Co-development w/ stakeholders
- Responsive to emerging needs & bloom changes

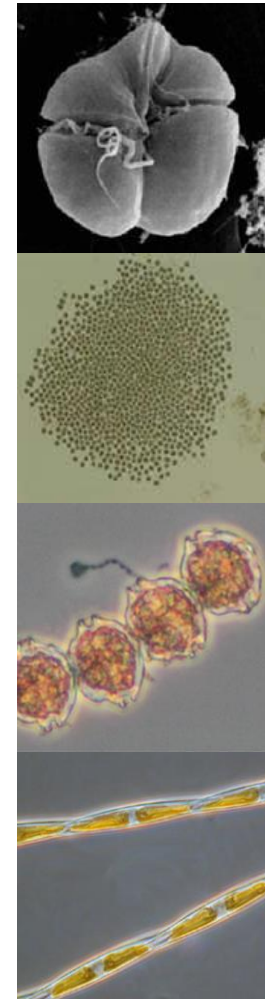
Move from reactive to proactive management

Multiple Pathways for Development

| Forecast System | HAB/Hypoxia Stressor | Status | Research | Service Delivery |
|--|--|---------------|----------|-------------------|
| Gulf of Mexico | <i>Karenia brevis</i> | Deployed | Internal | Internal (NCCOS) |
| Lake Erie | <i>Microcystis</i> & Hypoxia | Deployed | Both | Internal (NCCOS) |
| Gulf of Maine | <i>Alexandrium catenella</i> | Deployed | External | Internal (NCCOS) |
| Pacific Northwest | <i>Pseudo-nitzschia</i> | Deployed | External | External (NANOOS) |
| California Coast | <i>Pseudo-nitzschia</i> | Deployed | External | External (SCCOOS) |
| Coastal Maine | <i>Alexandrium catenella</i> | Deployed | External | External (ME) |
| Lake Okeechobee | <i>Microcystis</i> | Development | Internal | External (USACE) |
| Chesapeake Bay | <i>M. polykrikoides</i> & <i>A. monilatum</i> | Development | Internal | Internal (NCCOS) |
| Gulf of Alaska | <i>Alexandrium catenella</i> | Research | Internal | Internal (NCCOS) |
| GoMex seasonal forecast & bloom movement | <i>Karenia brevis</i> | Demonstration | External | External (USF) |

HAB & Hypoxia Forecast Case-Studies

1. *Karenia brevis*, Gulf of Mexico Forecast:
 - Internally developed & operated
2. *Microcystis* & Hypoxia, Lake Erie Forecast:
 - Cross-NOAA developed & transitioned to NCCOS for operations
3. *Alexandrium catenella*, Gulf of Maine Forecast:
 - Externally developed & transitioned to NCCOS for operations
4. *Pseudo-nitzschia*, Pacific Northwest Forecast:
 - Externally developed & operated



Gulf of Mexico HAB Forecast

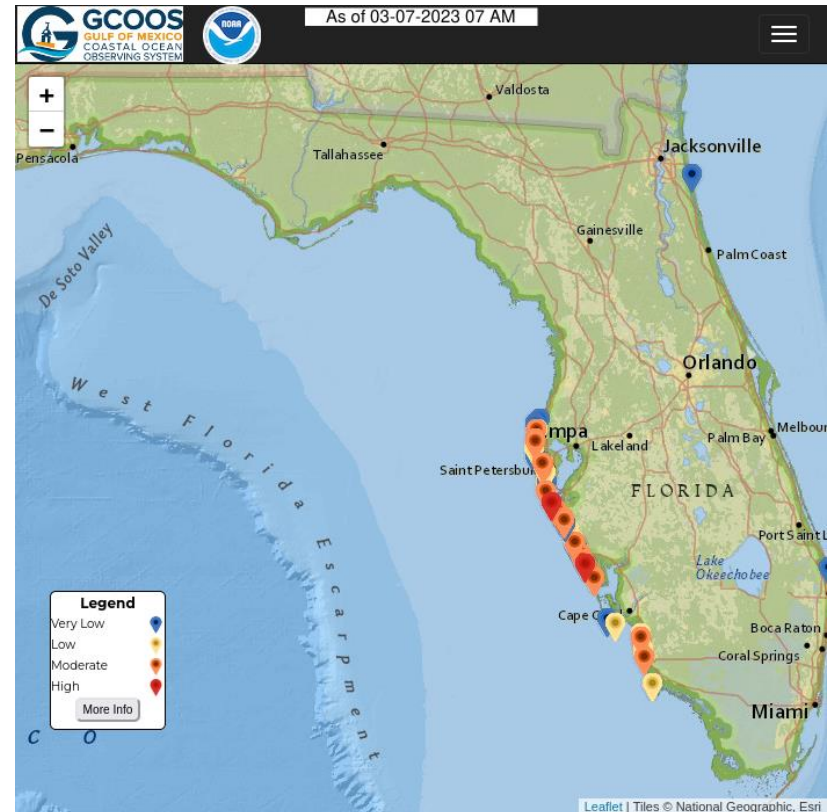
Presenter: Richard P. Stumpf, Ph.D.
HAB Forecasting Branch, NCCOS

Forecast Lead: HAB Forecasting Branch, NCCOS



Addressing Public Health Risks

- Red tide (*Karenia brevis*) blooms nearly annually along the Florida Gulf Coast
- Negative impacts include:
 - Respiratory & eye irritation in humans
 - Neurotoxic Shellfish Poisoning (NSP)
- Blooms are patchy: impacts vary with time & location
- Advanced warning needed to limit health impacts of blooms



Products:

- Nowcasts, forecasts, & HAB monitoring provide info. on *K. brevis* location & impacts
- Developed for FL Gulf Coast; includes all FL & TX coastlines

Use:

- Early warning of negative impacts of *K. brevis* blooms at local to regional scales
- Beachgoers; County & State Managers; Public Health Officials; Community members

GoMex HAB Forecast

Key Partners:

- NOAA NCCOS HAB Forecasting; NOAA NWS; GCOOS; FWRI; Pinellas Co.; Sarasota Co.; SCCF; Mote Marine Laboratory
- Community scientists

Current Status:

- Internally developed & operated forecast w/ regional partners
- Next Gen. Forecast developed in response to stakeholder needs
- Additional updates prioritized to meet needs

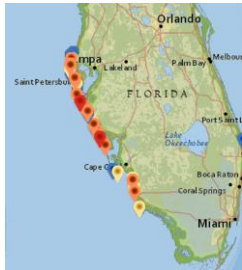
GoMex HAB Forecast System - Florida

Product Use

Components/Partners

Targeted End-User

Respiratory Forecast

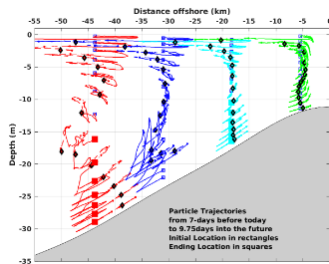


36 hr forecast of respiratory irritation at individual beaches along the FL Gulf Coast

- Cell counts from state, county, & community partners (GCOOS)
- NWS wind forecasts
- Respiratory reports from Mote, Pinellas Co.

- Beachgoer
- Community members
- State & county public health officials
- State & county managers

Intensification Forecast



10-day nowcast & forecast of the risk of *K. brevis* initiation or intensification along the SW FL Coast

- Cell counts from state, county, & community partners (GCOOS)
- Hydrodynamic model from academic partners (HYCOM)
- NWS wind forecasts

- State & county public health officials
- State & county managers
- Academic, state, & local researchers

Satellite Nowcast

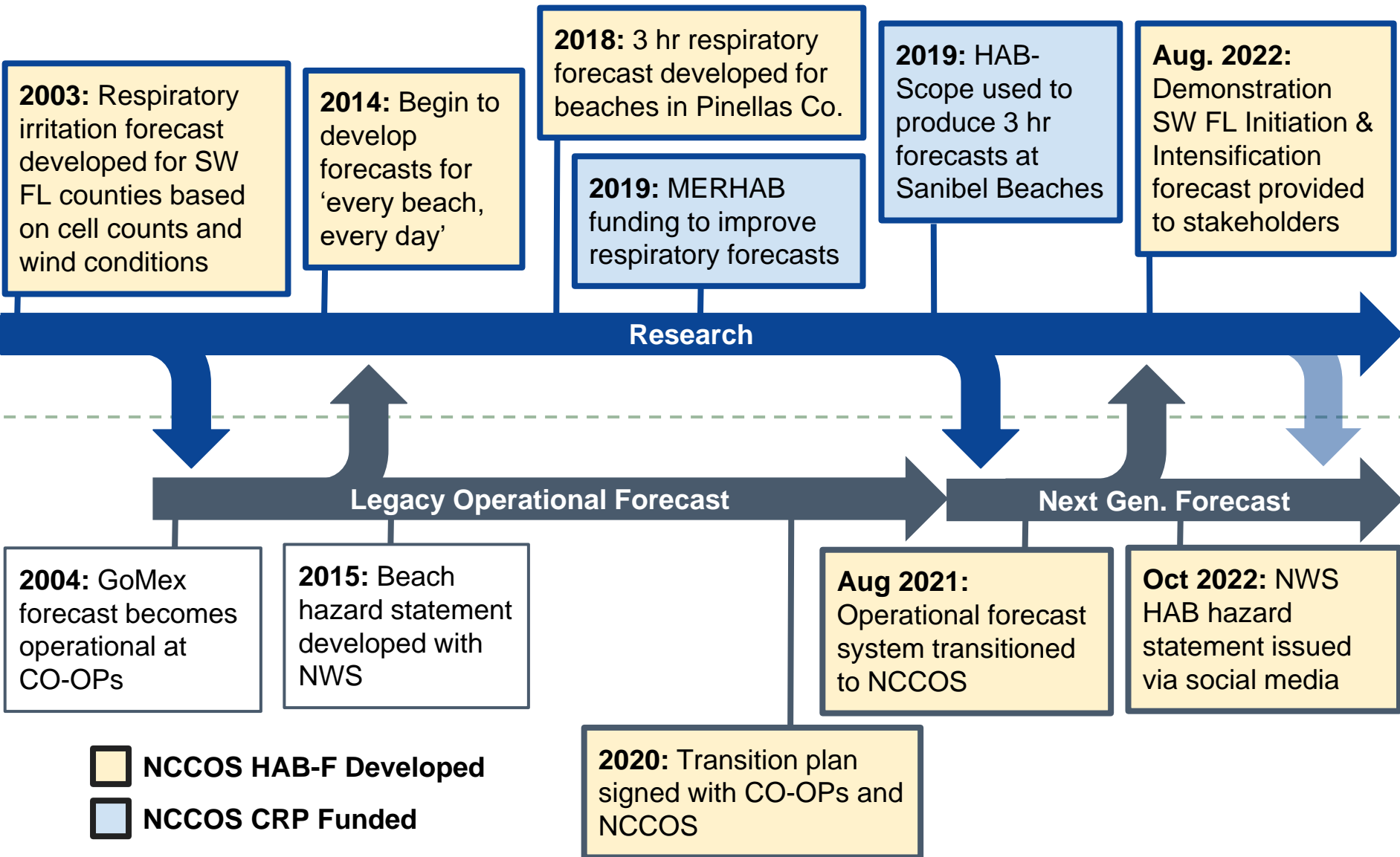


Nowcast of current bloom conditions along the FL Gulf Coast

- Cell counts from state, county, & community partners (GCOOS)
- Satellite imagery from Copernicus EUMETSAT, processed by NCCOS

- Community members
- State & county public health officials
- State & county managers
- Academic, state, & local researchers

Investment in Research & Deployment



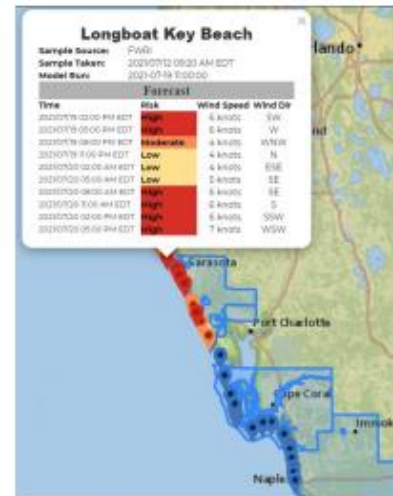
Responding to Stakeholder Needs

- *K. brevis* blooms are patchy - Better spatial & temporal resolution needed
- “Every beach, every day” - Partnered w/ GCOOS to increase monitoring via HABScope
- Providing more support to managers - Early warning of blooms

Legacy Forecast
2004-2021



Next Gen. Forecast
2021-Present



Moving from Research to Operations

Benchmarks for success:

- *Research:* Use cell counts + wind dir./spd. to estimate respiratory irritation
- *Demonstration:* Use microscope counts & HABScope to produce forecasts every 3 hrs at specific beaches
- *Operations:* Transition to NCCOS & expand to GoMex wide 'every beach, every day'

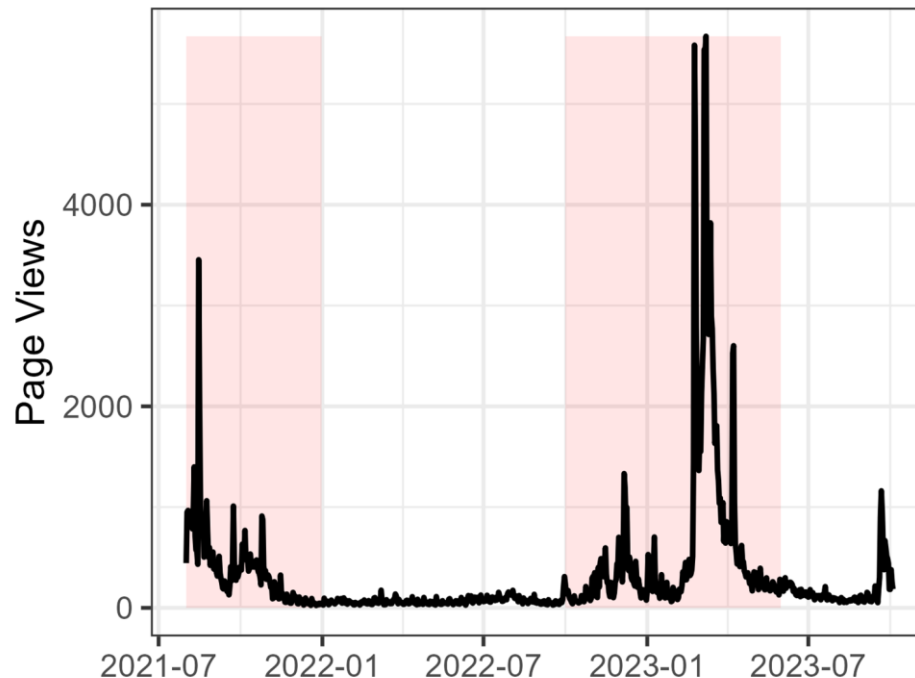
Resources needed:

- NCCOS commitment to operational forecasts
- Transition plan & team from CO-OPs to NCCOS
- Multi-year demonstration & transition period
- Commitment from partners to maintain data collection
- IT infrastructure
- Long-term commitments for both research & operations

Multiple Methods of Service Delivery

- **Forecast Webpage** - General public; beachgoers; local residents; tourists
- **NWS HAB Alerts via Social Media** - General public; TV & radio media; beachgoers; local residents
- **Weekly Email Bulletin** - Long-term end-users; state & county managers; public health officials
- **FWRI Red Tide Coordination meeting** - State managers & public health officials
- **Inquiries/feedback to hab@noaa.gov** - General public; county managers; local residents; tourists
- **Peer Reviewed Publications** - Academic, Federal, & State Scientists
- **Outreach** – News & media articles

Documenting & Assessing Product Use

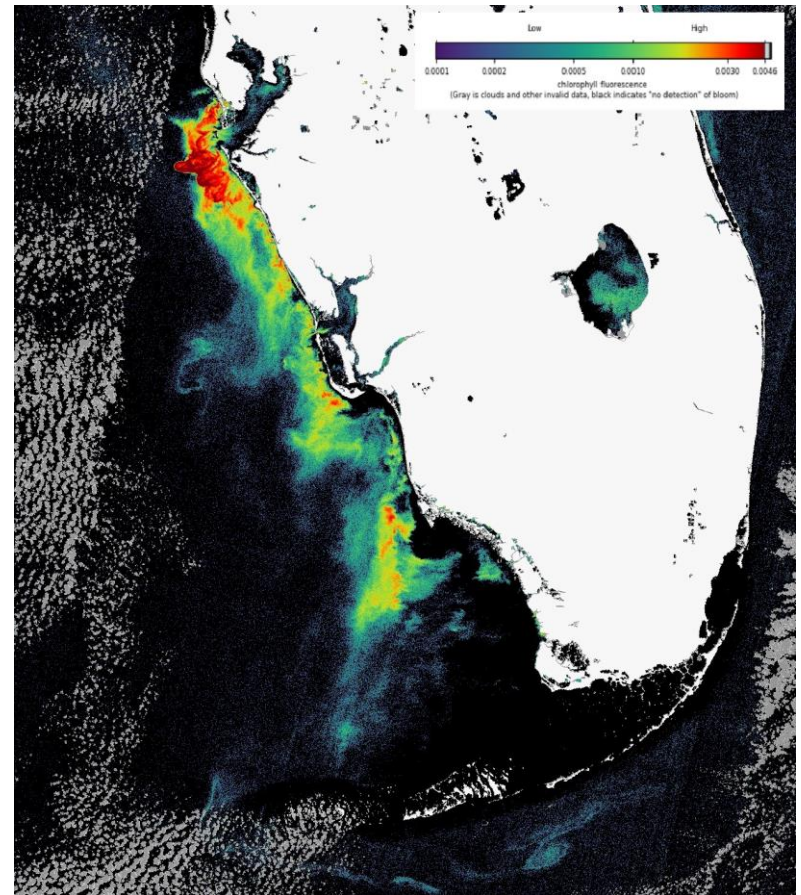


- Engagement metrics:
 - >240,000 web page views
 - >7,000 email subscribers
 - >237,000 people reached via social media from Jun. 2022-2023
- FAMU survey to assess forecast use

“We find the HAB forecasts incredibly useful for communicating to our viewers... There is always strong demand for information regarding the potential effects of red tide...” -*Jason Dunning (Meteorologist, WBBH-TV, Ft. Myers, FL)*

Maintaining & Expanding Forecast Use

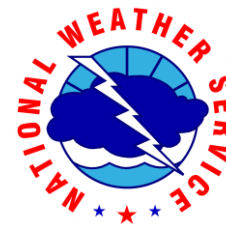
- Improving operational status (2023: >99.9% operational)
- Address stakeholder needs:
 - Improve forecast visualizations
 - Additional data to expand forecast locations
 - Invest in field data for model & forecast validation
- Investment in R&D is critical to maintain forecast relevance & quality



Quality, Relevance, & Performance

| | Quality | Relevance | Performance |
|-----------------------------|--|---|---|
| Service Delivery | <ul style="list-style-type: none"> • Multiple, targeted delivery methods • Updated delivery methods following changes in technology/best practices | <ul style="list-style-type: none"> • Update to Next Gen. forecast following needs • Multiple, targeted products • Identify & address issues | <ul style="list-style-type: none"> • >99.9% forecast delivery (2023) • Methods in place to ensure successful forecast delivery |
| Research Transitions | <ul style="list-style-type: none"> • Extensive investment in research to incorporate new technology | <ul style="list-style-type: none"> • Substantial updates following ‘<i>every beach, every day</i>’ • Incorporated stakeholder feedback during development | <ul style="list-style-type: none"> • Transition plan & team from CO-OPs to NCCOS • Long-term investment in personnel & infrastructure |

Forecast System Relies on Partnerships



Questions?

Lake Erie HAB & Hypoxia Forecast

Presenter: Richard P. Stumpf, Ph.D.

HAB Forecasting Branch, NCCOS

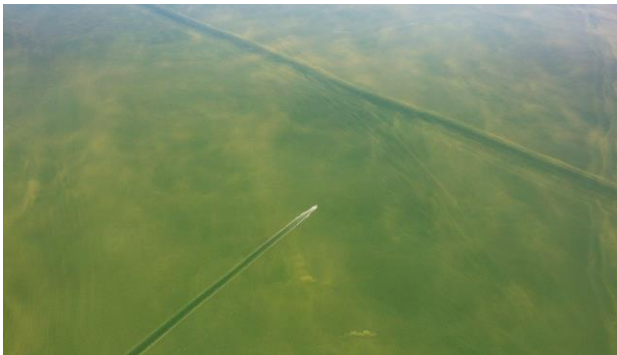
Forecast Lead: HAB Forecasting Branch, NCCOS &
NOAA GLERL



Multiple Environmental Stressors

HABs:

- Annual blooms of cyanobacteria in the Western Basin
- HAB toxins & scums pose risk to human health & drinking water
- Identify when & where impacts will occur



Hypoxia:

- Hypoxia ('dead-zone') impacts the Central Basin annually
- Leads to fish kills, ecological community changes, & degraded drinking water
- Early warning of hypoxic events



Products:

- HAB nowcasts, seasonal & short-term forecasts, & monitoring products
- Dissolved oxygen nowcasts, forecasts, & early warning system

Use:

- Proactive management of utilities
- Water treatment managers; County & State Managers; Public Health Officials; Fishers; Fisheries Managers

LE HAB & Hypoxia Forecast

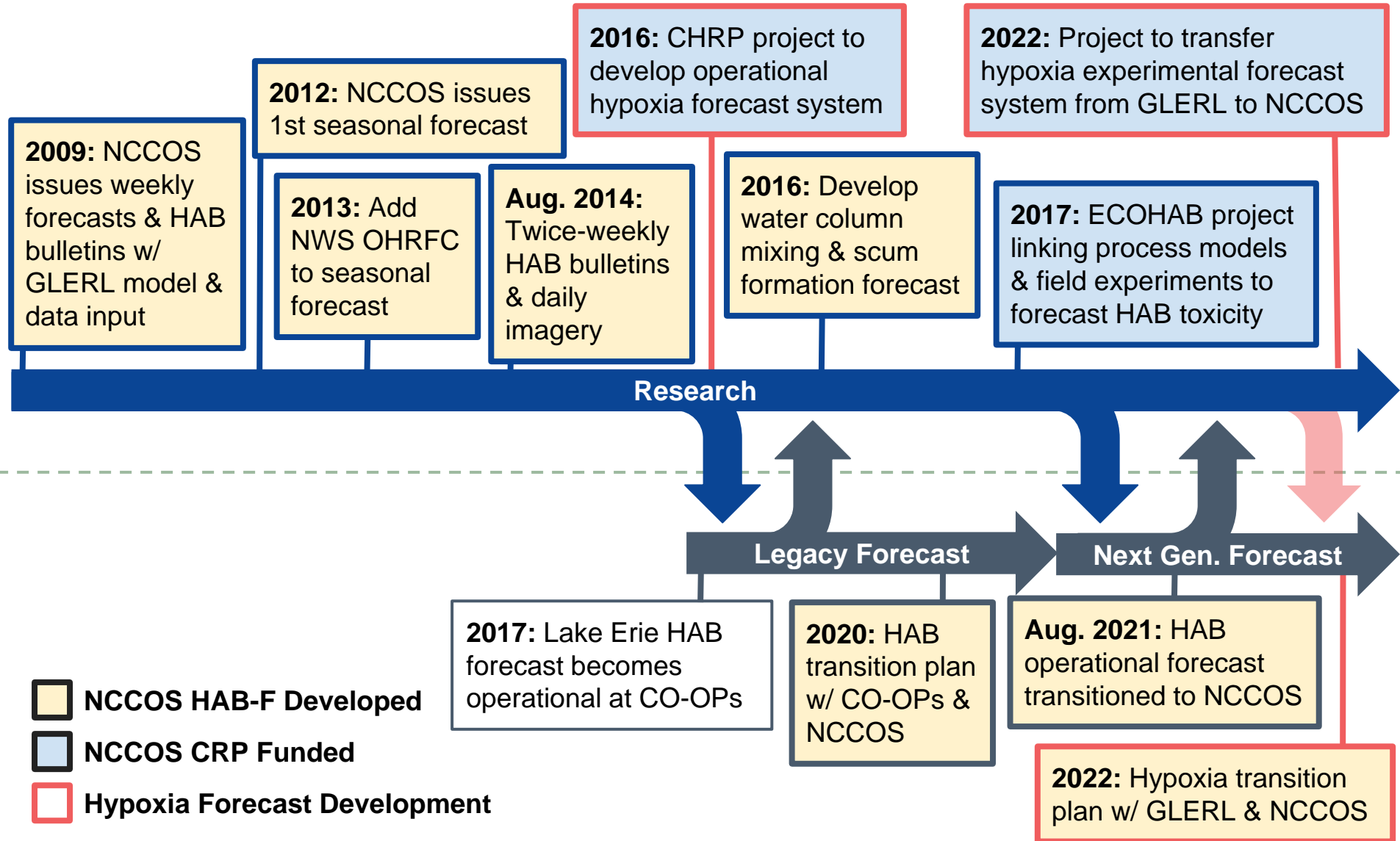
Key Partners:

- NOAA NCCOS HAB Forecasting; NOAA NWS; NOAA GLERL; NOAA CO-OPs; GLOS; Heidelberg U. NCWQR; OH Sea Grant; Regional Water Treatment Plants

Current Status:

- HABS: NCCOS developed w/ GLERL models & transitioned to NCCOS for operations
- Hypoxia: GLERL developed forecast & transitioning to NCCOS for operations

Co-development of Multiple Forecasts



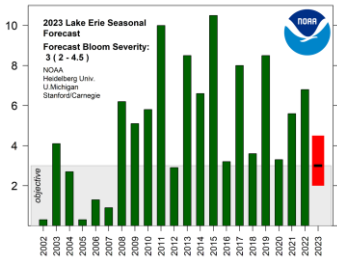
W. Lake Erie HAB Forecast System

Product Use

Components/Partners

Targeted End-User

Seasonal Forecast

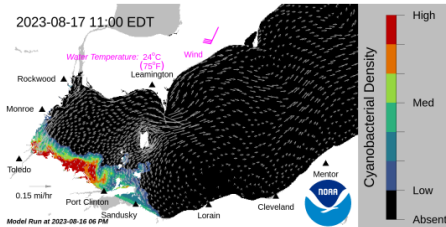


Seasonal forecast of cyanobacteria bloom intensity - issued in late Jun.

- NWS OHRFC river forecasts
- NCWQR, Heidelberg U. nutrient loads
- Ensemble models from academic partners

- Federal & state agencies
- Water treatment plant operators
- State & county managers
- Elected officials

Forecasted Bloom Position

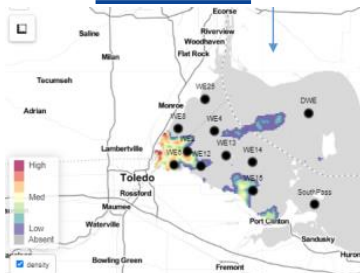


Nowcast & 3-day forecast of bloom location & intensity in western Lake Erie

- Copernicus Sentinel-3 satellite imagery
- NOAA CO-OPs hydrodynamic model
- NOAA GLERL & NDBC field data
- NWS forecasts

- Fishers, tourists, community members
- Federal & state agencies
- Water treatment plant operations
- Health depts.

Vertical Mixing Forecast



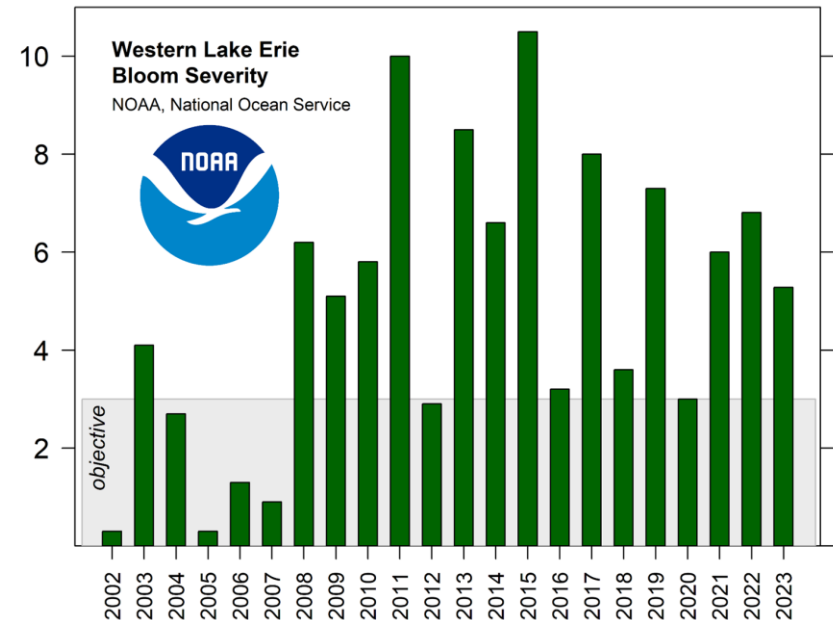
Nowcast & 3-day forecast of water column mixing & scum formation

- Copernicus Sentinel-3 satellite imagery
- NOAA CO-OPs hydrodynamic model
- NOAA NDBC wind
- NWS wind forecasts

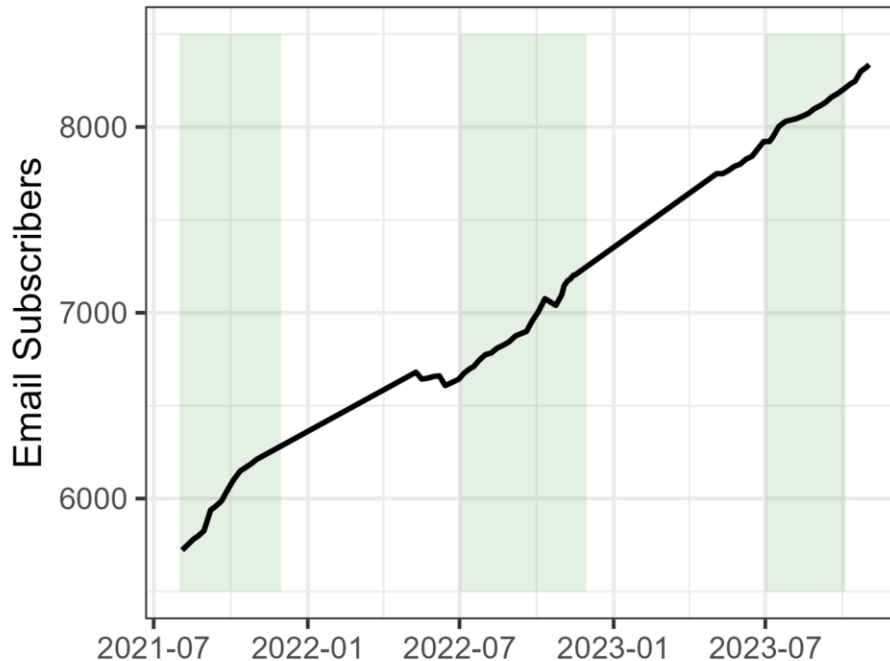
- Fishers, boat operators
- Water treatment plant operators
- State & county managers

Supporting Management Decisions

- Seasonal forecast - water treatment operators, elected officials
- Nowcast/short-term forecast - early warning for water intake impacts
- Models & forecasts help set nutrient reduction targets (US EPA, GLWQA Annex 4)
- Support annual OH EPA reporting for western, central, & eastern Lake Erie
- R&D supported by Great Lakes Restoration Initiative (EPA)



Multiple Methods of Service Delivery



- Engagement metrics:
 - >95,000 web page views
 - >8,000 email subscribers
 - 16 elected officials participated in Seasonal Forecast webinar

“The NOAA HAB forecast helps Monroe prepare for the HABs before they get close to our city water intakes. We use the forecasts to help water treatment plant operators.... Without the NOAA HAB forecast... we would not have any warning of HAB locations and the direction they are heading.”

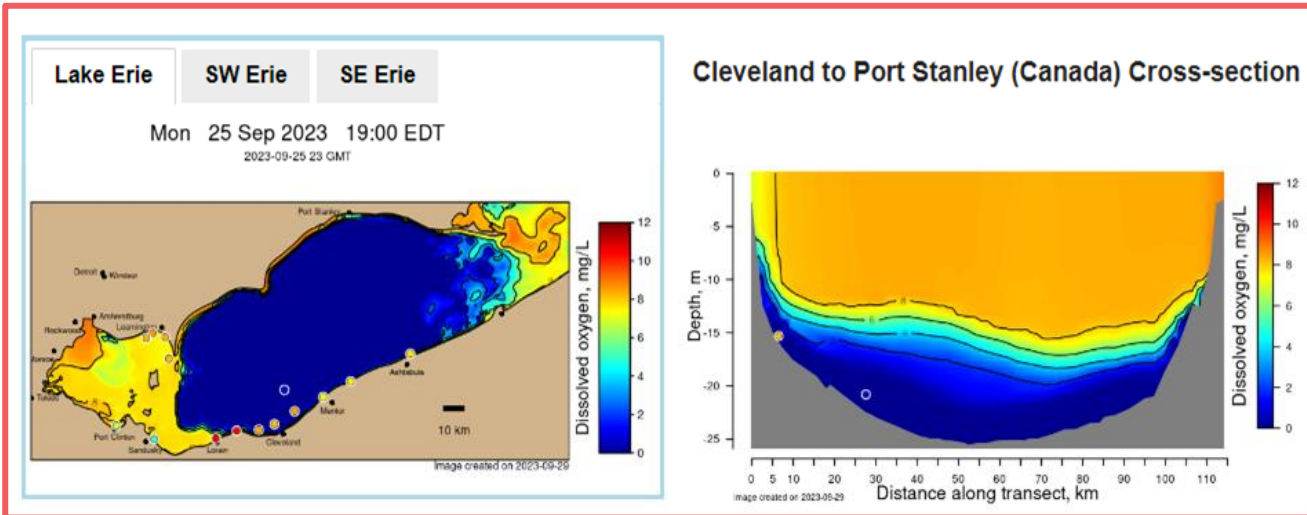
-Chris Knight (City of Monroe, MI)

GLERL Lake Erie Hypoxia Forecast

Forecast date: 2023-09-21

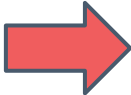
Select different forecast year: Select different forecast date:

[Back to the main Lake Erie Hypoxia Forecast archive page](#)



Dissolved oxygen 5-day forecast - surface (left) & depth (right)

Email bulletin of potential hypoxic upwelling event



Experimental Lake Erie Hypoxia Forecast Update

Potential Central Lake Erie Upwelling Event September 22-25

Stakeholder Decision Making

- Provide 6-8 hypoxic event warnings annually to ~150 email subscribers
- Stakeholders: Water treatment operators; state & federal managers; fishers
- Focus groups to co-develop forecasts

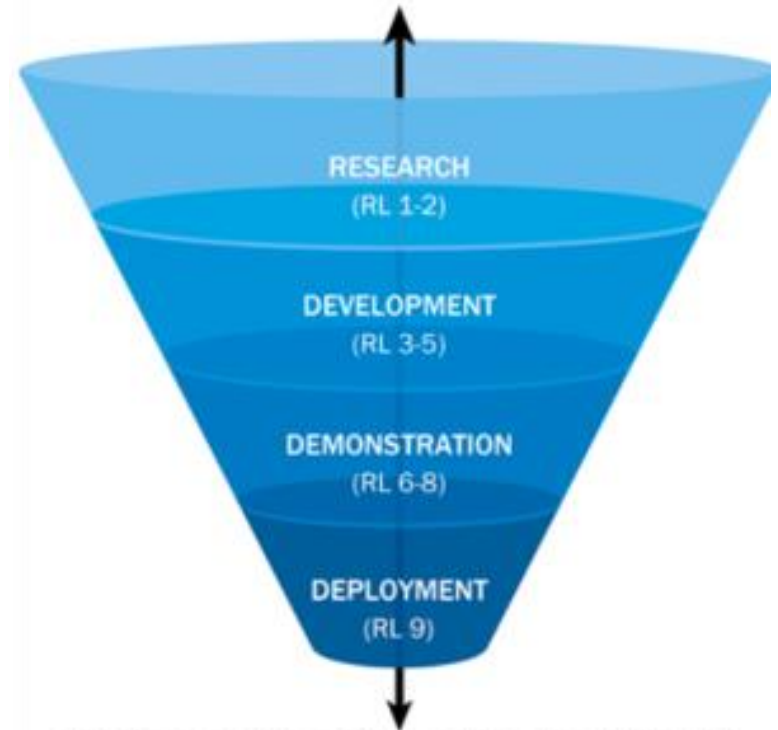
Socio-economic Impact:

- 18 public utilities affected
- 2 million people impacted
- ~\$2-10 million economic impact of a large event

“Since we’ve been getting those [hypoxia forecast] emails, we haven’t been caught unaware...in the past the color change, the temperature drop is when we’re finding out about it. At that point, it’s already in the plant...The forecast changed that.” -*Water Treatment Operator (2020 GLERL Focus Group)*

Transition from Research to Operations

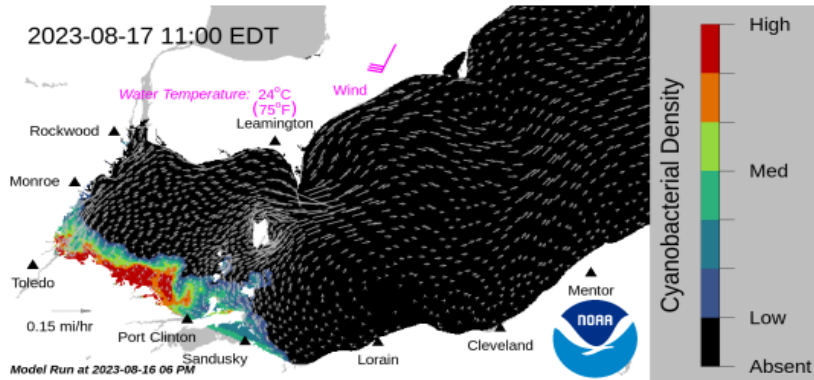
- Multi-year transition from GLERL to NCCOS for operations
 - Experimental (GLERL): 2017-2021
 - Transition plan (GLERL/NCCOS): 2022
 - Demonstration (NCCOS): 2022-2023
 - Operational (NCCOS): Summer 2024 (est.)



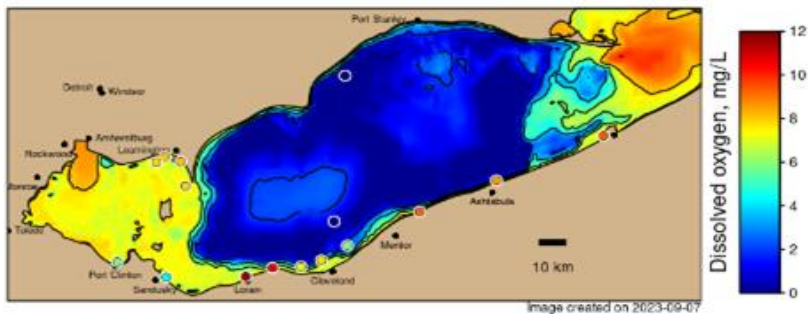
NOAA's research transition readiness levels "funnel" connecting research with application.

Multi-Stressor Forecast System

HAB Forecast:



Hypoxia Forecast:

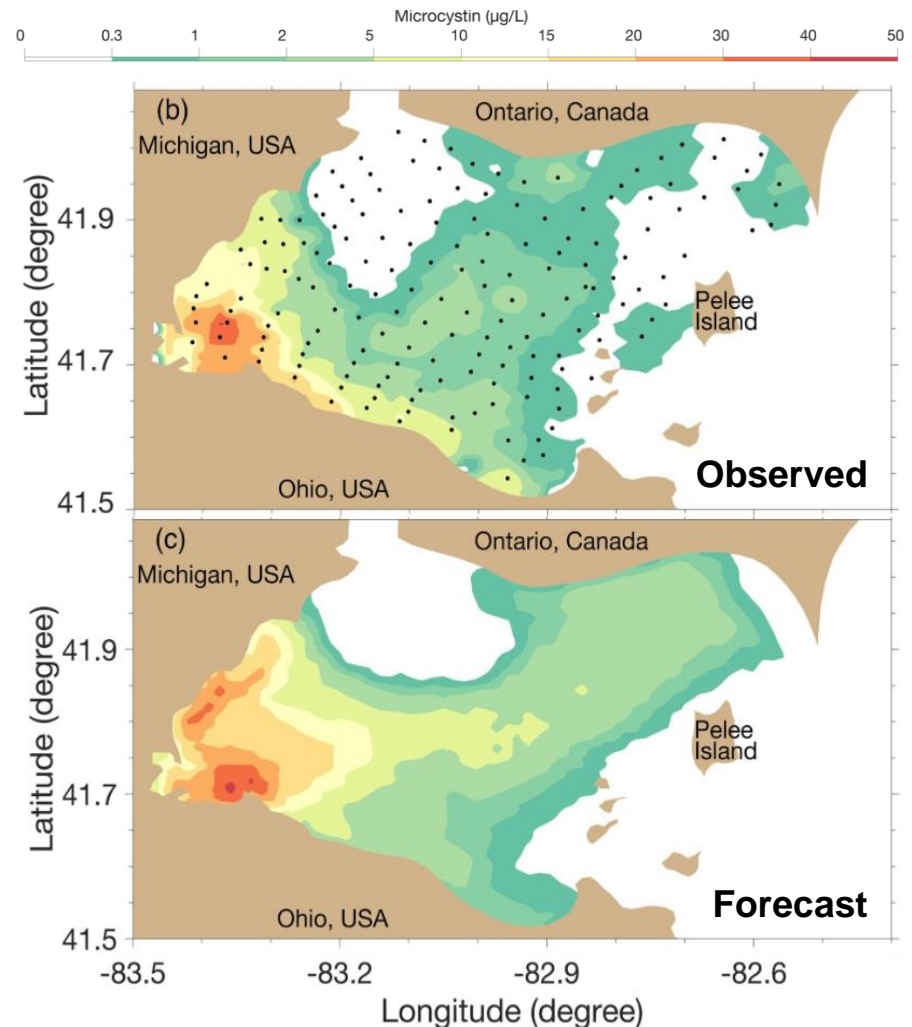


- Leverage existing capabilities:
 - Overlapping stakeholders
 - Efficiency gains using current forecasting platform
 - Utilize existing personnel expertise
- Challenges exist:
 - Additional personnel training & effort
 - Research to maintain relevance
 - Incorporate new capabilities, visualizations for existing system

Future Capabilities to Meet Needs

- R&D to maintain forecast relevance & accuracy:
 - Develop new models for seasonal forecast
 - Forecast water column concentrations
 - Include HAB toxin potential
 - Engage additional hypoxia stakeholder groups
- Investment in R&D is necessary to maintain relevance in a changing climate

Potential HAB Toxin Model



Zhou et al. (2023)

Quality, Relevance, & Performance

| | Quality | Relevance | Performance |
|-----------------------------|--|--|--|
| Service Delivery | <ul style="list-style-type: none"> • Targeted delivery methods • Leverage stakeholder groups for both forecasts | <ul style="list-style-type: none"> • Increasing product use over time • 'One-stop-shop' for multi-stressor forecasts | <ul style="list-style-type: none"> • Daily web bulletins produced during bloom season • Forecasts/models directly support management decisions |
| Research Transitions | <ul style="list-style-type: none"> • Collaborations with multiple NOAA offices • Extensive research & validation | <ul style="list-style-type: none"> • Forecast R&D aimed at increasing accuracy, relevance • Incorporated stakeholder feedback during development | <ul style="list-style-type: none"> • Transition plan & team from CO-OPs to NCCOS • Long-term investment in personnel & infrastructure |

Multiple Data & Model Providers



Questions?

Gulf of Maine *Alexandrium catenella* Predictive Models

Presenter: Quay Dortch, Ph.D.

CSS Senior HAB Scientist, NCCOS

Former NCCOS ECOHAB Program Coordinator & PCMHAB Program Manager

Forecast Lead: HAB Forecasting Branch, NCCOS

Paralytic Shellfish Poisoning (PSP)

- Potentially fatal poisoning syndrome from contaminated shellfish
- Caused by recurrent population blooms of *Alexandrium catenella*
- Significant economic losses result from shellfish harvesting closures



Source: WHOI / J. Kleindinst

Products:

- Nowcasts & forecasts provide information on the location, movement & growth of blooms
- Dashboard provides an integrated analysis of bloom potential

Use:

- Provide context for shellfish bed closures & testing frequency decisions made by state shellfish managers along the NE coast (ME, MA, NH)

GoME HAB Forecast

Key Partners:

- NOAA NCCOS HAB Forecasting; NE River Forecast Center; OMAO; WHOI; NERACOOS
- ME Dept of Marine Resources; MA Division of Marine Fisheries; NH Dept of Envir. Services

Current Status:

- Externally developed/tested w/ NCCOS support & transferred internally to NCCOS for sustained operations
- Working to expand coverage & address other HAB species

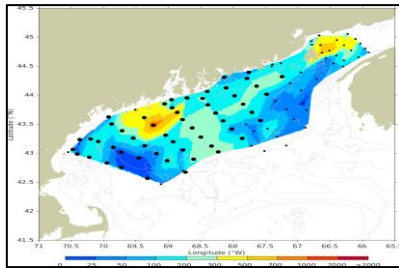
Gulf of Maine – HAB Forecast System

Product Use

Components

Application

Seasonal Forecast

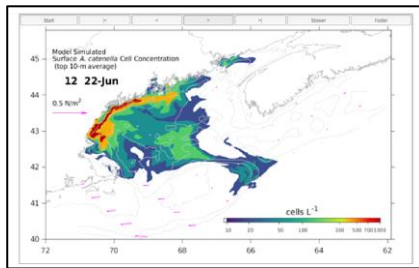


Seasonal forecast of **bloom severity** from annual cyst survey (Released early May)

- Based on the number of *Alexandrium* cysts found in the sediment and model predictions

- Better planning for resourcing/staffing needs of State shellfish managers

Nowcast/Forecast

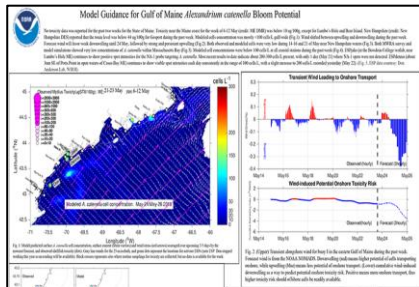


Nowcast & 3-day forecast for Gulf of Maine ***Alexandrium* concentrations** (Weekly: May-Jul)

- Wind, solar radiation, tidal constituents, heat fluxes, river discharge, SST, nutrient fields, population model for *Alexandrium*

- Advance warning to aid in shellfish testing frequency & location decisions

Dashboard



***Alexandrium* bloom potential** dashboard synthesis product (Weekly: May-Jul)

- Integration of wind, ESP data, observed shellfish toxicity & modeled cell concentration

- Robust & integrated information on expected impacts of identified blooms

Investment in Research and Operations

2011-2016: PCMHAB: Implementation of an operational model for prediction of HABs in the GoME

2019-2024: HABON-NE, An adaptive observing network for real-time, In Situ HAB monitoring & data sharing across New England

2006-2014: ECOHAB: Dynamics of *Alexandrium* distributions in the GoME: An observational & modeling study of near- & offshore toxicity

2015-2018: ECOHAB: Interannual variability of PSP toxicity in eastern ME: testing the leaky gyre hypothesis & improving regional forecasts

2023-2028: MERHAB: Early warning for amnesic shellfish poisoning in the GoME through real time *in situ* characterization of upstream phytoplankton blooms

1997-2006: ECOHAB & MERHAB projects to understand & model toxic *Alexandrium* blooms in the GoME



2006-2013: Experimental weekly nowcast/forecast run at WHOI

2007: WHOI began issuing Seasonal Forecast

2014-2017: Transition from WHOI to NCCOS

2017-Current: Forecast run at NCCOS

2018: 1st Dashboard Product

NCCOS CRP Funded
 NCCOS HAB-F Developed

Transition from Academia to NCCOS

Progress

- Model platform testing/validation led to increased accuracy
- Added new model processes, capability to model blooms nearshore, & new bloom potential dashboard
- Dedicated & sustained funding to facilitate transfer

Challenges

- Based on different model platform than NOAA
- Large system w/ localized impacts - need for enhanced monitoring & targeted forecasts
- Loss of operational partner & need to develop research infrastructure at NCCOS
- Transition plan needed for full operational status

Funding: NCCOS Competitive Research Funding: 1997-2018
NCCOS Internal HAB Forecasting Support: 2016-Current

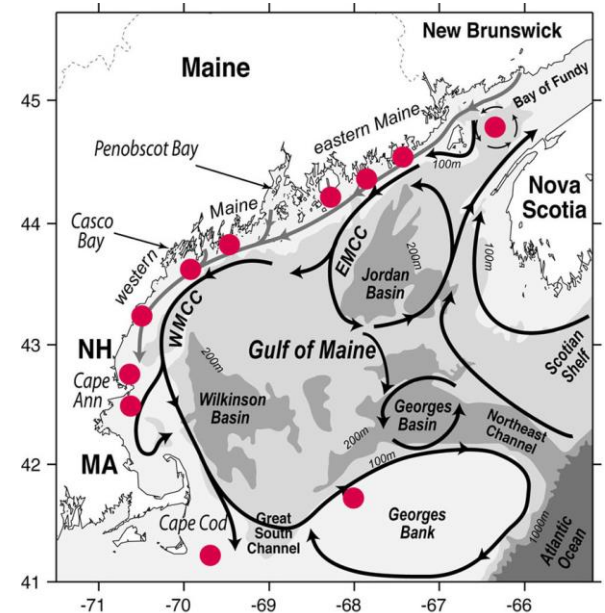
Method of Service Delivery

Annual GOM HAB Science Symposiums:

- Started out as MTAGs (circa 2002)
- Now key annual stakeholder event
- Critical forum for information exchange

Meeting Outcomes:

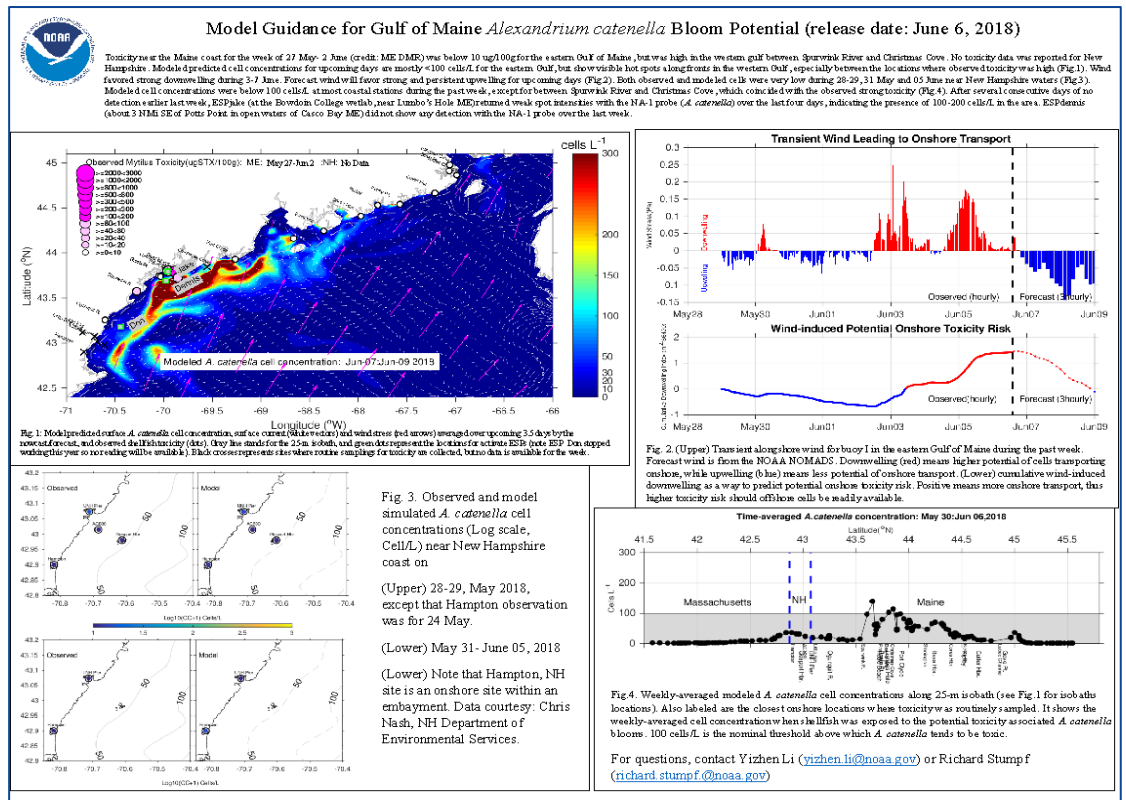
- Accelerated adoption of forecast products
- Identifying research priorities
- Optimized placement of monitoring assets
- Utility & accuracy of forecast products
- Refinement of new forecast products
- Model coordination for other regions



Source: Anderson laboratory, WHOI (red dots, manager proposed locations of ESPs in 2003)

Responding to Stakeholder Needs

- Development of bloom potential synthesis product
- Expansion of forecasts to include near-shore areas around Mass. bay & along coast
- Research to address emerging threat of Amnesic shellfish poisoning (ASP)



Emerging Stakeholder Needs

- Expansion to other stakeholder communities
- Predictions of closure probability
- Site-specific information for near-shore shellfish production & harvesting
- Ecosystem changes impacting HABs



Source: Maine Aquaculture Roadmap 2022-2032

Quality, Performance, & Relevance

| | Quality | Relevance | Performance |
|-----------------------------|---|---|--|
| Service Delivery | <ul style="list-style-type: none"> • Forecasts provide accurate & timely information to GOM stakeholders during bloom season • Annual stakeholder workshops | <ul style="list-style-type: none"> • Used to help manage high value economic shellfisheries • Decisions have broad implications to affected communities | <ul style="list-style-type: none"> • Extensive collaboration w/ partners to assess product use & value • Published assessments of economic value |
| Research Transitions | <ul style="list-style-type: none"> • Substantial investments in R&D over multiple funding cycles • NCCOS facilitated transition from R2A | <ul style="list-style-type: none"> • Stakeholder feedback incorporated during development | <ul style="list-style-type: none"> • Transition plan in development to move into full operations • Working to address additional stakeholder needs |

Partnerships to Support Forecast



ME Department of Marine Resources



MA Division of Marine Fisheries



NH Dept of Environmental Services



Woods Hole Oceanographic Institute



North East River Forecast Center



Office of Marine and Aviation Operations



IOOS NERACOOS

Questions?

Pacific Northwest HAB Bulletin



Presenter: Quay Dortch, Ph.D.

CSS Senior HAB Scientist, NCCOS

Former NCCOS ECOHAB Program Coordinator & PCMHAB Program Manager

Forecast Lead: Ryan McCabe, Ph.D.

Research Physical Scientist, PMEL



HAB Impacts on PNW Communities

- Annual blooms of *Pseudo-nitzschia* (PN) produce neurotoxin
- Amnesic shellfish poisoning (ASP) caused by eating the toxic shellfish
- Shellfish managers monitor toxins & close fisheries resulting in economic losses



Products:

- Integrated monitoring & forecasting provides critical info. to PNW shellfisheries managers
- Understand onset, duration, & magnitude of toxin outbreaks

Use:

- Information on bloom location, movement, & toxicity
- WA Depts. of Health & Fish and Wildlife; OR Depts. of Agriculture Fish and Wildlife; Coastal Treaty Tribes

PNW HAB Bulletin

Key Partners:

- NOAA PMEL; NCCOS CRP; NOAA NWFSC; NANOOS; JISAO; OR Dept. of Fish & Wildlife; ORHAB; Makah Tribe; Quinault Indian Nation; WA Dept. of Fish & Wildlife; WA Dept. of Health

Current Status:

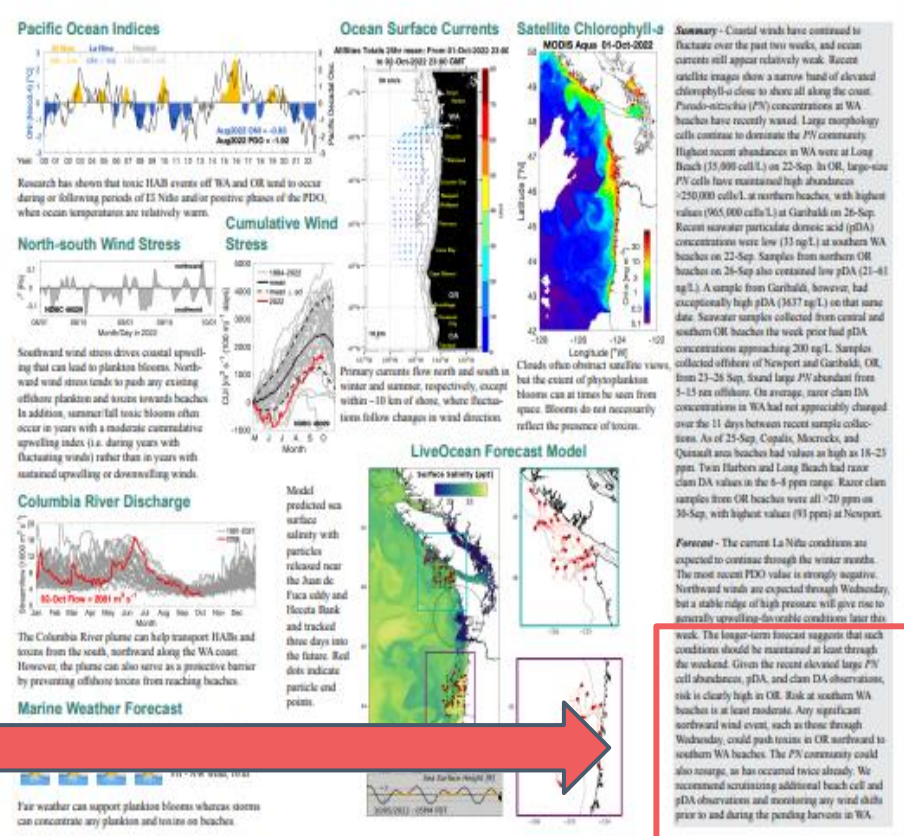
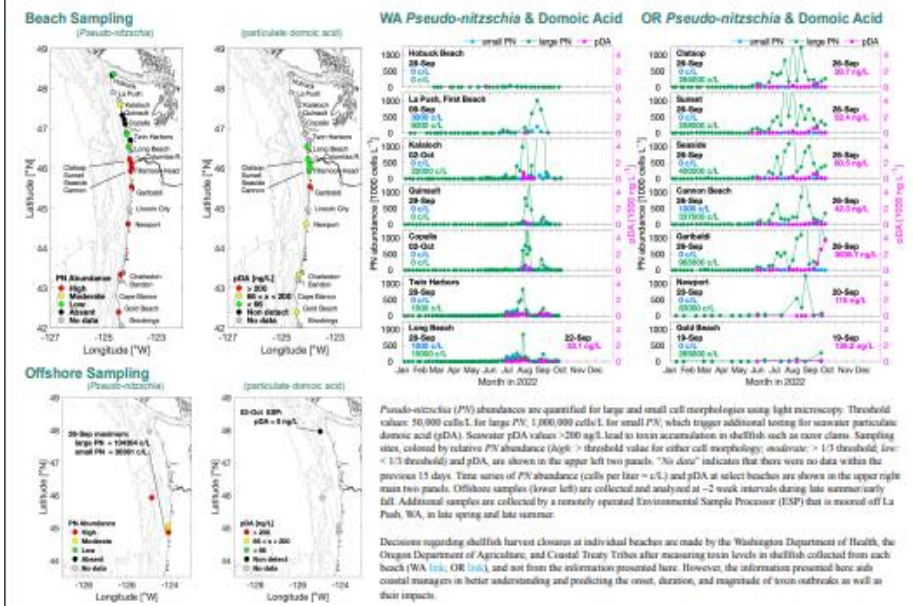
- Externally developed & operational product, w/ support from NCCOS
- Produced several times a year during the PN season by PMEL & hosted by NANOOS

Pacific Northwest - HAB Bulletin

Pacific Northwest Harmful Algal Blooms Bulletin
 Oct 3, 2022 HAB risk = **High**

HAB risk key:
 ● = low
 ● = medium
 ● = high

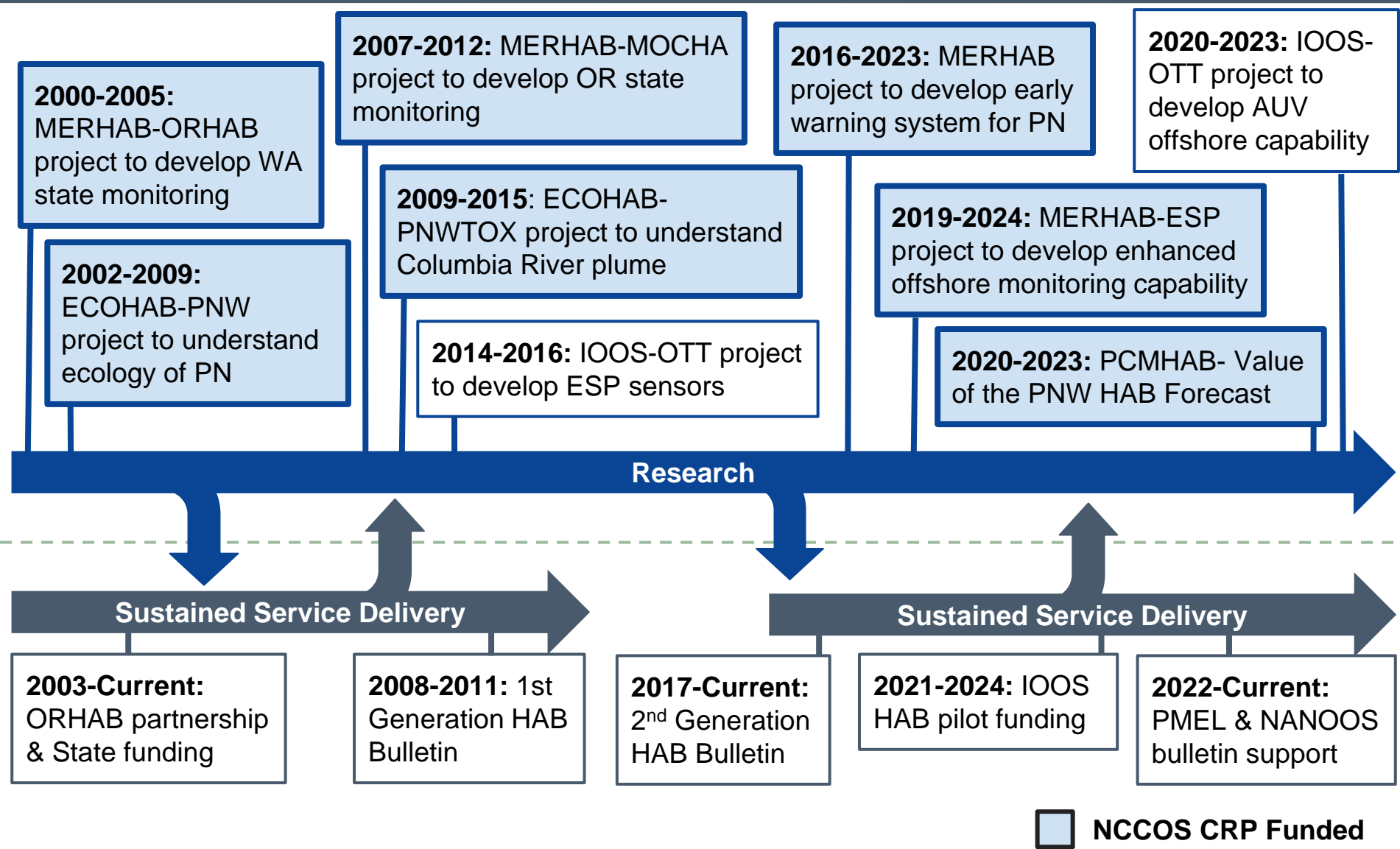
HAB risk based on PN & toxin monitoring



Forecast summary based on monitoring & particle transport model

Fair weather can support plankton blooms whereas storms can concentrate any plankton and toxins on beaches

Investment in Research & Delivery



Responding to Stakeholder Needs

- 1st Generation Bulletin produced from 2008-2011
- 2nd Generation Bulletin initiated in 2017
 - NCCOS regional project to develop an early warning system
- Continuation of the bulletin, upgrades, & pathway toward sustained funding
- Leverage State monitoring efforts & offshore monitoring

1st Generation Bulletin

- Coverage: WA
- No larger-scale ocean indices
- Physical circulation model w/ rudimentary particle tracking
- Sporadic offshore sampling



2nd Generation Bulletin

- Coverage: WA & OR
- El Niño & Pacific Decadal Oscillation risk factors added
- Live Ocean forecasting model w/ particle tracking
- Dedicated offshore sampling

Moving from Research to Operations

Progress

- Bulletin transferred from UW to NANOOS w/ lead forecaster at PMEL
- Funding diversified from research to operations through NANOOS
- Draft transition plan developed in 2019

Challenges

- Limited “base funding”
- Sustained service delivery provided through multiple diverse funding sources
- Vulnerable to changes in partner priorities or funding (e.g., Gap from 2011-2017)

Recent Funding: U.S. IOOS via National HAB Observing Network (NHABON); NOAA Pacific Marine Environmental Laboratory (PMEL); *NCCOS Monitoring and Event Response for HAB (MERHAB) program*; Olympic Region HAB (ORHAB) partnership

NCCOS Support for External Forecast

- **Enable research based development** - early research needed to establish HAB monitoring & forecast development
- **Sustained funding** - enable bulletin to progress to deployment & gain stakeholder support
- **Funded regional, interdisciplinary projects** - ensure best management-relevant science is conducted & transitioned
- **Support multi-disciplinary teams** - Co-PIs included state & tribal partners and engagement in regional stakeholder meetings (i.e., ORHAB)
- **Provide a national framework** - NCCOS program managers provide integration between funding programs, regional entities, national initiatives (NHABON) & Congress

Quality, Performance, & Relevance

| | Quality | Relevance | Performance |
|-----------------------------|---|---|---|
| Service Delivery | <ul style="list-style-type: none"> • Bulletin provides accurate & timely info. to PNW stakeholders • Product integrates data from Federal, State, Academic & Tribal sources | <ul style="list-style-type: none"> • Used to manage high value economic & subsistence shellfisheries • Congressional interest in product & long-term sustainability | <ul style="list-style-type: none"> • Extensive collaboration w/ partners to assess product use • Documented instances of management utilization |
| Research Transitions | <ul style="list-style-type: none"> • Substantial investments in R&D over multiple funding cycles • NCCOS facilitated transition from R2A | <ul style="list-style-type: none"> • Stakeholder feedback incorporated during development • Broad user base of bulletin & components | <ul style="list-style-type: none"> • Formal transition plan in final development • Sustained delivery achieved through multiple funding sources |

HAB Bulletin Relies on Partnerships



OR Dept of Fish and Wildlife



WA Dept of Health



WA Dept of Fish and Wildlife



Quinault Indian Nation



The Makah Tribe



ORHAB



Hoh Indian Tribe



Cooperative Inst for Climate Ocean & Ecosystem Studies



Univ of Washington



NANOOS



OR Dept of Agriculture



Univ of CA Santa Cruz



Univ of Strathclyde



Northwest Fisheries Science Center



Joint Inst for the Study of the Atmosphere and Ocean



Quileute Tribe



Pacific Marine Environmental Laboratory

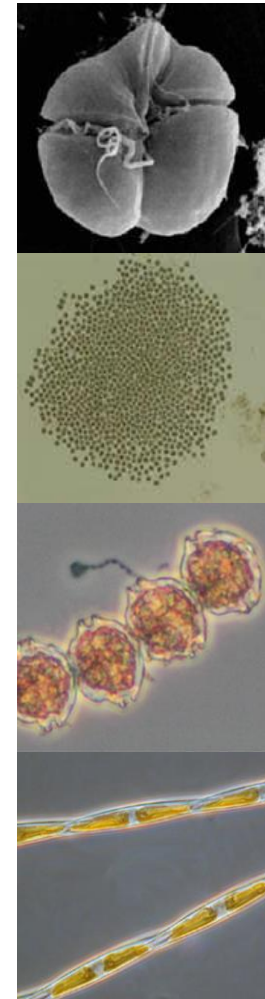
Questions?

NCCOS Supported HAB & Hypoxia Forecasting



National HAB Forecast Framework

- Systems are developed regionally but within a national framework
 - **Forecast systems contain multiple capabilities:** to meet different stakeholder needs
 - **Co-development w/ stakeholders:** via workshops, direct feedback, & as CO-PIs on research & transition grants
 - **Extensive partnerships:** including w/ IOOS RAs, State & County government agencies, Tribal communities, NOAA line offices
 - **Transition plans guide R2A decisions:** identify partners, dedicated resources, & guidelines for operations



Challenges & Opportunities

Challenges:

- Building a HAB operational forecast framework
- Balance research & operations
- Create buy-in for transition plans across organizations
- Extensive dependencies for monitoring & modeling
- Long timelines needed for research, development, & transition

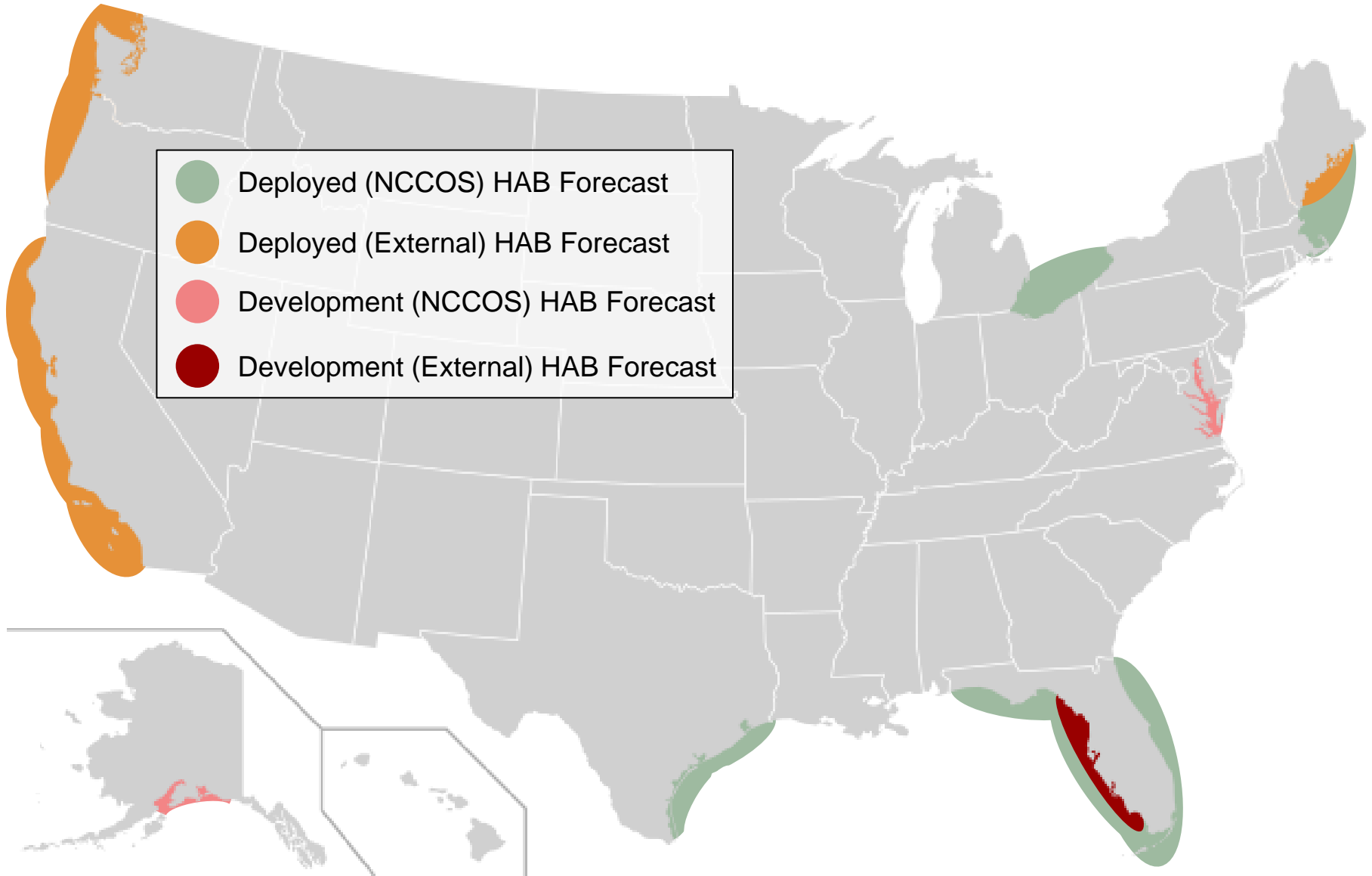
Opportunities:

- Framework for operational, ecological forecasting
- Cross-leverage systems
- Technology advancements lead to higher resolution, more accurate products
- Incorporating multiple metrics of HABs - i.e., toxicity, severity, biomass
- Benefit from operational observational & modeling systems

Multiple Pathways for Development

| Forecast System | HAB/Hypoxia Stressor | Status | Research | Service Delivery |
|--|--|---------------|----------|-------------------|
| Gulf of Mexico | <i>Karenia brevis</i> | Deployed | Internal | Internal (NCCOS) |
| Lake Erie | <i>Microcystis</i> & Hypoxia | Deployed | Both | Internal (NCCOS) |
| Gulf of Maine | <i>Alexandrium catenella</i> | Deployed | External | Internal (NCCOS) |
| Pacific Northwest | <i>Pseudo-nitzschia</i> | Deployed | External | External (NANOOS) |
| California Coast | <i>Pseudo-nitzschia</i> | Deployed | External | External (SCCOOS) |
| Coastal Maine | <i>Alexandrium catenella</i> | Deployed | External | External (ME) |
| Lake Okeechobee | <i>Microcystis</i> | Development | Internal | External (USACE) |
| Chesapeake Bay | <i>M. polykrikoides</i> & <i>A. monilatum</i> | Development | Internal | Internal (NCCOS) |
| Gulf of Alaska | <i>Alexandrium catenella</i> | Research | Internal | Internal (NCCOS) |
| GoMex seasonal forecast & bloom movement | <i>Karenia brevis</i> | Demonstration | External | External (USF) |

Questions?



Executive Session

Review Panel only

Dinner at Mandalay following
6:00PM

(930 Bonifant St, Silver Spring, MD 20910)



NCCOS Annual Science Review: Harmful Algal Blooms and Hypoxia Program

Silver Spring, Maryland
28 - 30 November, 2023

Review Website: [NCCOS HABs and Hypoxia Program Review](#)



WELCOME BACK AND RECAP

Lonnie Gonsalves
Peg Brady






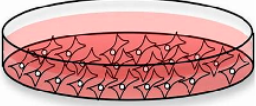
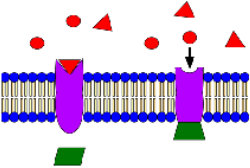

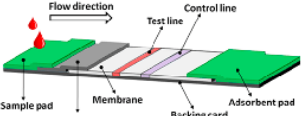
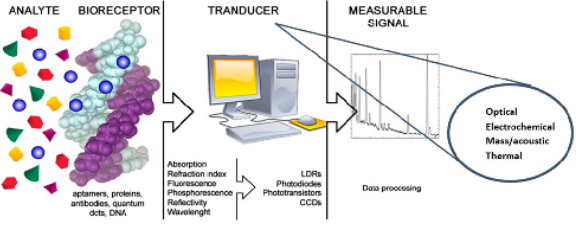
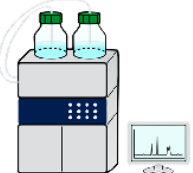
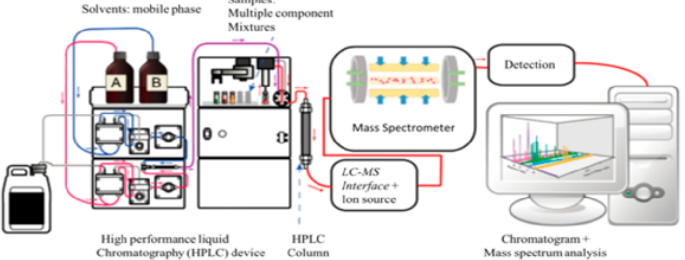
Toxin Detection

“Eliminate HAB poisonings”

2023 NCCOS HAB & Hypoxia Review



Toxin Detection Approaches

| | | | |
|-----------------------------------|--|--|--|
| <p>BIOLOGICAL METHODS</p> |  <p>Mouse bioassay</p> |  <p>Cell based Assays</p> |  <p>Receptor based Assays</p> |
| <p>BIOCHEMICAL METHODS</p> |  <p>ELISA</p> |  <p>Lateral flow devices</p> |  <p>Biosensor Methods</p> |
| <p>CHEMICAL METHODS</p> |  <p>HPLC-UV HPLC-FLD</p> |  <p>LC-MS/MS</p> | |

Toxin Detection

Rapid and accurate identification and quantification of HAB toxins is a direct measure of risk for the reduction of HAB poisonings

NCCOS provides:



Experts



Funding



Facilities

NCCOS has many touch points throughout service delivery & research transitions

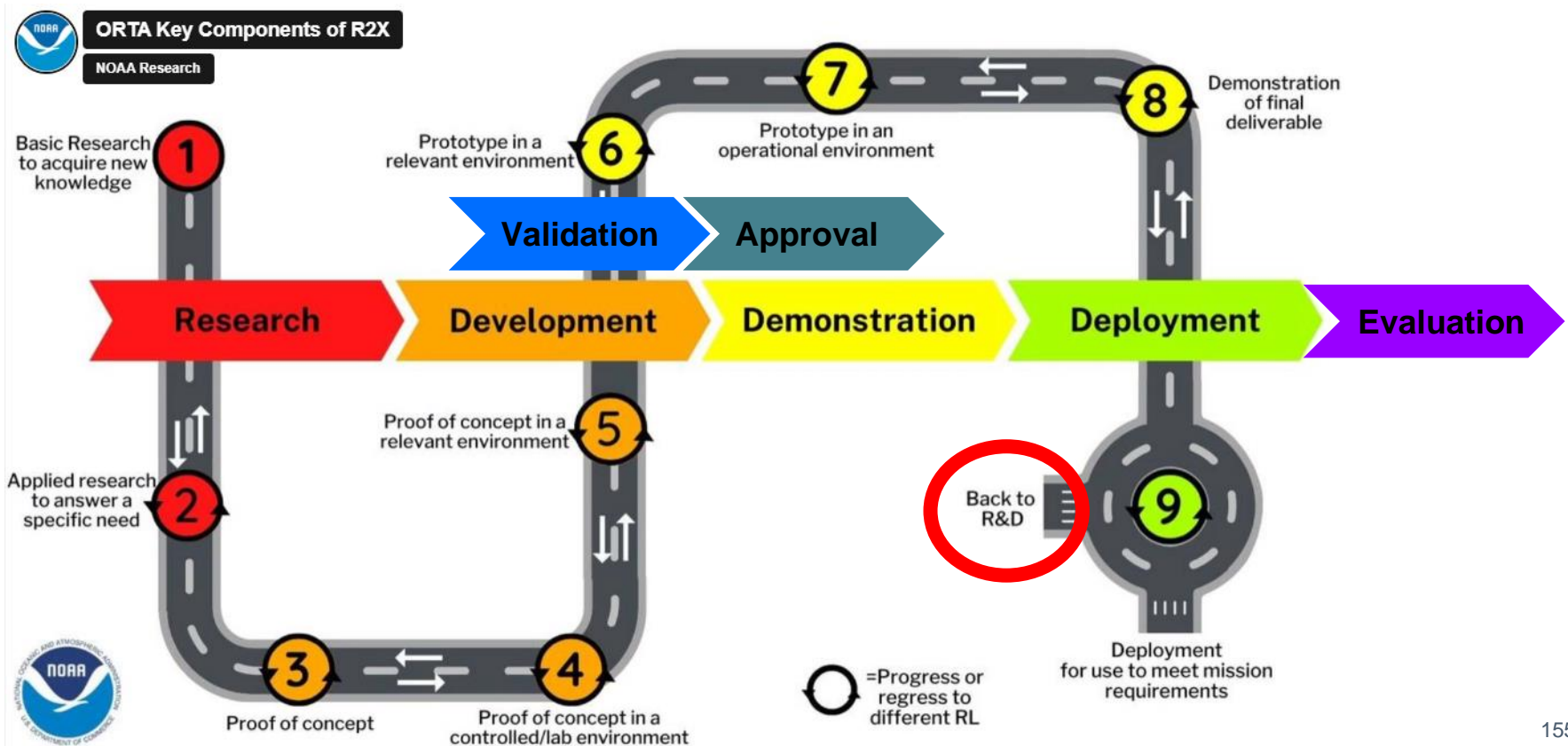
NCCOS empowers coastal managers and communities with validated and approved tools to inform decisions and issue consumer warnings about HAB toxins.

What: Co-developing toxin detection tools through strong relationships to respond to various user needs.

How:

1. Training stakeholders to implement standardized HAB toxin detection capabilities
2. Advancing regional HAB toxin detection solutions with a national perspective (standardized >> approved methods)

Tool development is an adaptive process



Service Delivery & Research Transitions

NCCOS is improving toxin detection by shepherding the development, acceptance, and implementation of new and/or improved technologies

R2O

Research to
Operations

R2C

Research to
Commercialization

R2A

Research to
Application

R20

Implementation and Expansion of User Laboratories

Case Study: *Alaska Tribal Laboratories*

***Sustained, Reliable Mission Activity with an Institutional
Commitment to Deliver Products***



Target end products and geographic application

**Eliminate HAB
poisonings**

- Alaska communities fill the knowledge gap
- Saxitoxin receptor binding assay

**Protect Human
Health**

Target uses and user groups

**Recreational
harvesters**

- Tribal consortia:
Southeast Alaska Tribal Ocean Research,
Chugach Regional Resources Commission

**Subsistence
harvesters**

NCCOS units and partners involved

**NCCOS
Charleston**

- Sitka Tribe of Alaska Environmental Research Lab
- Alutiiq Pride Research Institute

**Alaska
Natives**

**NCCOS
CRP**

Current state of product and next steps

receptor-based

- Operational use of approved saxitoxin RBA
- Capacity developing for emerging toxins
- Resource for other tribes outside the region

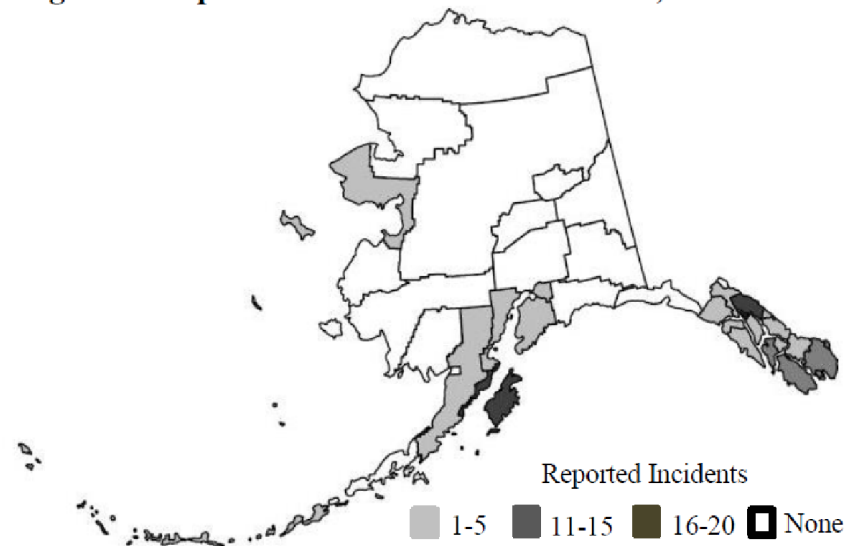
antibody-based

R2O: Alaska Tribal Laboratories

ISSUE: Communities need toxin detection tools to make informed decisions and issue warnings to consumers about HAB toxins in the absence of a systematic recreational/subsistence monitoring program.

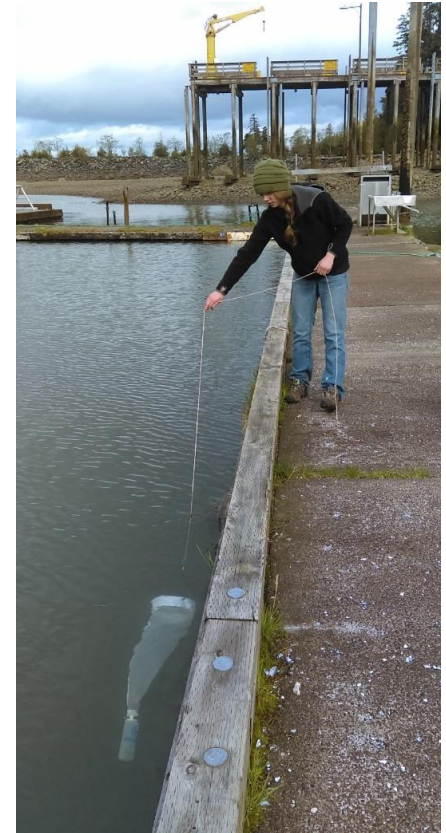
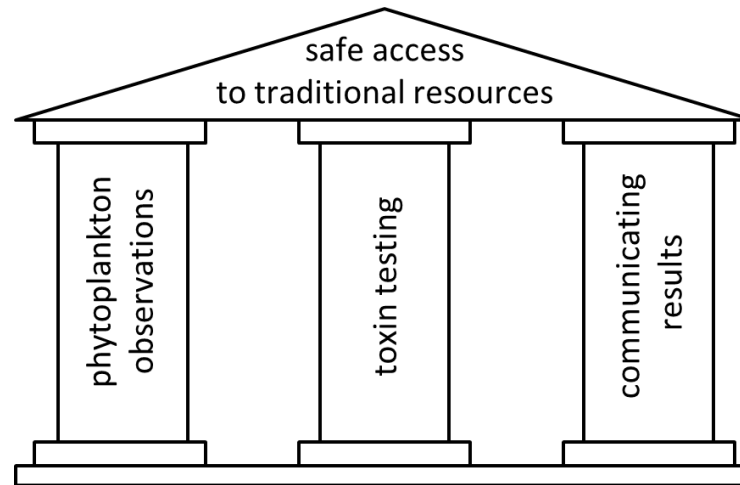
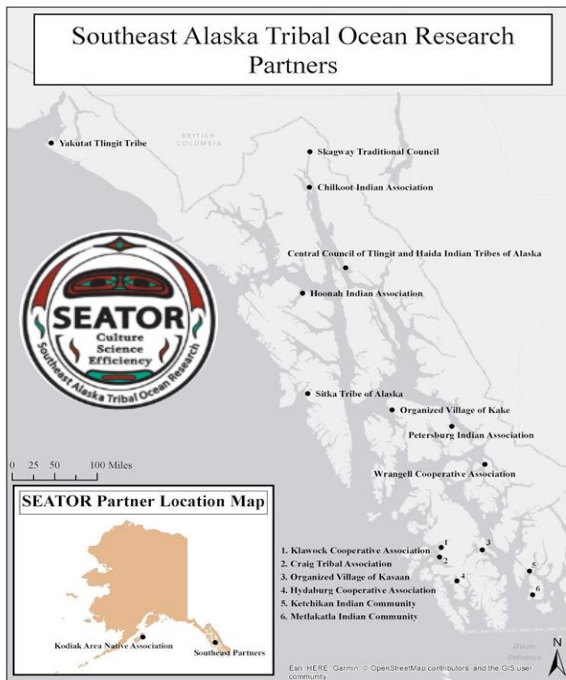
- Alaska Dept Environmental Conservation monitors extensively for saxitoxins, but only in commercial harvests.
- **Poisonings require improved knowledge of toxin presence.**

Figure 2. Reported PSP Incidents — Alaska, 1993–2021





2015 - Alaskan communities create community of practice to monitor HABs through phytoplankton monitoring





2016 - NCCOS Charleston developed saxitoxin receptor binding assay (RBA) added to FDA National Shellfish Sanitation Program approved list (capacity to respond)

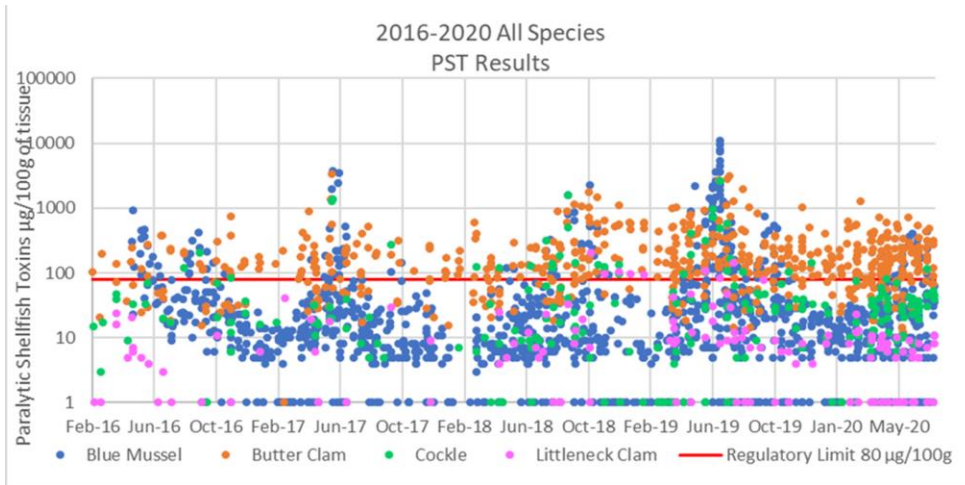
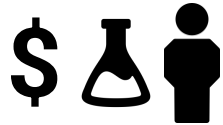


2017-present - NCCOS Charleston provides training, guidance, and support to bring saxitoxin testing to support community harvests in a newly formed laboratory (Sitka Tribe of Alaska Environmental Research Lab 'STAERL')

Saxitoxin monitoring is currently providing harvest data, with no documented illness from any community harvest sites



2024-2026 - NCCOS Charleston, Sitka Tribe's lab & Washington Department of Health to close the data gap needed for full FDA acceptance of saxitoxin RBA with validation of clams & oyster matrices (PCM HAB)



Harley et al (2020) Toxins



Domoic acid & diarrhetic shellfish toxin (DST) producing algae identified through community monitoring, increasing concerns about the harvest risks



2020-present - NCCOS Charleston and Sitka Tribe's lab develop toxin testing capacity for domoic acid & DSTs using MERHAB funding



Lessons Learned

Developing community testing approach on a wider scale has region specific challenges and requires different interaction/timescales in order for the partner to take the lead.

Continued NCCOS involvement over a timeline longer than a grant cycle is key to building capacity.

Not all tools end up in the targeted audience (e.g. FDA methods at State regulatory agencies).

Additional investment and time may be needed to enhance impact to NCCOS products.

“when the tide goes
out the table is set”

B.C. folklore society
Brian Robertson

Overview

| QUALITY | RELEVANCE | PERFORMANCE |
|---|--|--|
| <ul style="list-style-type: none"> • Validation and implementation of toxin detection tools continues to advance for matrices and methods relevant to community needs. | <ul style="list-style-type: none"> • Impact of toxin detection tools without precedence. • Co-developed products enhance results | <ul style="list-style-type: none"> • Solutions to control food safety by applying effective technologies • Investment and evaluation of current and future needs continues |

Questions about this case study?



R2C

Developing a Point-of-Need Toxin Detection Platform
Case Study: *LightDeck® Technology*

Introducing Technology into the Commercial Market



Target end products and geographic application

Point of Need Testing **Nationwide**

- Rapid testing for shellfish or water
- Different products for freshwater & marine

Target uses and user groups

Resource Managers **Commercial & Recreational**

- Canandaigua Lake Watershed Assn
- State Univ NY- ESF

NCCOS units and partners involved

NCCOS CRP & Charleston **Academic** **Private Company**

- LightDeck (mBio)
- Limnotech
- The Ohio State Univ Stone Lab
- Washington Dept Health

Current state of product and next steps

Biological (antibody-based) **Accuracy & reliability testing**

- Validation efforts underway for ISSC
- Revision of extraction procedures

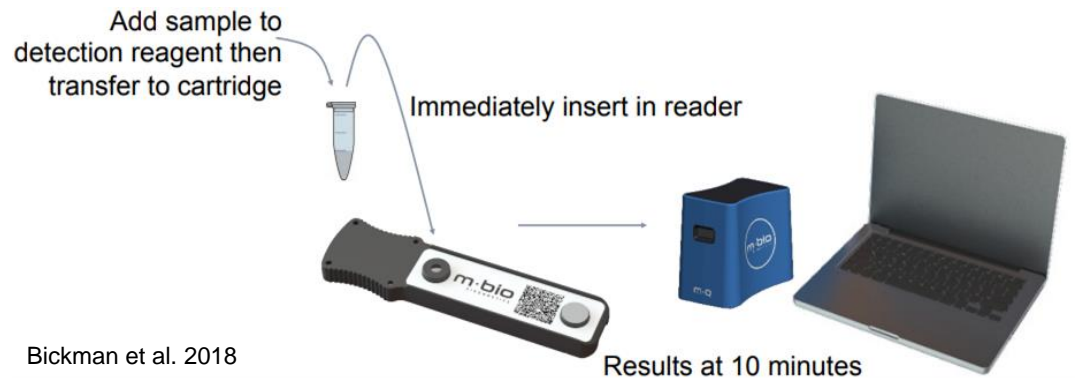
R2C: LightDeck Technology

ISSUE: Need for accessible and accurate toxin testing to support rapid decision making to protect public health from toxins



R2C: LightDeck Technology

- WHAT IS IT?
 - Antibody-based toxin detection and quantification
 - Rapid, portable, planar waveguide technology platform
 - Uses inexpensive, disposable test cartridges
- RELEVANCE:
 - Cost/time improvements, multi-toxin tests, field testing
 - Better testing access >> reduced risk



Bickman et al. 2018

R2C: LightDeck Technology

LightDeck Example 1: Rapid, portable, multiplexed detection of HAB toxins in the Great Lakes

- Media: freshwater
- Toxins: MC, CYN, ATX, STX
- Targeted application: water monitoring

LightDeck Example 2: Multiplexed detection of HAB toxins in shellfish

- Media: shellfish
- Toxins: DA, PST, (DST)
- Targeted application: food safety / regulatory



2012 - Early communication w/NCCOS Charleston (brevetoxin-based applications)



2017 - LightDeck personnel visit NCCOS Charleston lab



NCCOS Charleston conducts LC-MS/MS to determine congener information



NCCOS collaborates with LightDeck to optimize testing platform



2019 - [MERHAB](#) “Portable Toxin Detection Technology to Support Great Lakes Decision Support Tools” **Validate** and deploy MC/CYN field testing





2020 - [PCM HAB](#) “Rapid, portable, multiplexed detection of harmful algal toxins in the Great Lakes” Develop and **validate** additional toxin assays for platform



2020 - [PCM HAB](#) “**Validation** of a triplex test for saxitoxin, domoic acid, and okadaic acid measured in shellfish tissue from New England and the Pacific Northwest” Obtain regulatory “Approval for Limited Use” of technology through validation



  2020 - [Citizen Science Field Testing](#) w/ NCCOS Phytoplankton Monitoring Network

 2020 - [Virtual Training Workshop](#)

 2022 - Validation: Comparison of LightDeck & ELISA using environmental samples w/ NCCOS Charleston

Demonstration in an operational environment: SUNY-ESF (partner) working with Canandaigua Lake Watershed Association (end user)

Lessons Learned

Successes

- NCCOS co-developing product with industry, facilitating transition
- Value of partnering early with end users: adaptive development
- Trainings future end users to use new technology/product

Challenges

- Validation and demonstration with natural water samples
 - detection limits
- Cell lysis
 - portable lysis system (USACE)
 - freeze-thaw cycles (cannot be done in field)
- Different toxins require different extraction procedures
- Ephemeral nature of commercial companies

Overview

| QUALITY | RELEVANCE | PERFORMANCE |
|--|---|--|
| <ul style="list-style-type: none"> • Validating reliability and accuracy of method with rigorous, iterative testing. • Product development is concurrent with the transition through the service delivery process. | <ul style="list-style-type: none"> • Meets need for more efficient testing at the point-of-need. • Incorporating target users and relevant field sites/samples into technology development and demonstration. | <ul style="list-style-type: none"> • Incorporation of target users throughout R2X (e.g., researchers, citizen scientists). • Direct communication between the commercial developer and target users. |

Questions about this case study?



R2A

Developing Analytical Detection Methods for Regulatory Use Case Study: *LC-MS for Diarrhetic Shellfish Toxins*

Use of R&D Output as a System, Process, Product or Tool



Target end products and geographic application

**Eliminate HAB
Poisonings**

Nationwide

- Analytical detection of Diarrhetic Shellfish Toxins (DSTs) to ensure safe harvests

Target uses and user groups

**Resource
Managers**

**Commercial &
Recreational**

- Washington State Dept Health
- Maine Dept Marine Resources
- event response

NCCOS units and partners involved

**NCCOS CRP &
Charleston**

**State/Fed
Agencies**

**Int'l Gov.
Agencies**

- FDA CFSAN & FDA Office Regulatory Sci
- Washington State Dept Health
- Bigelow Lab for Ocean Sci
- Netherlands Institute for Food Safety

Current state of product and next steps

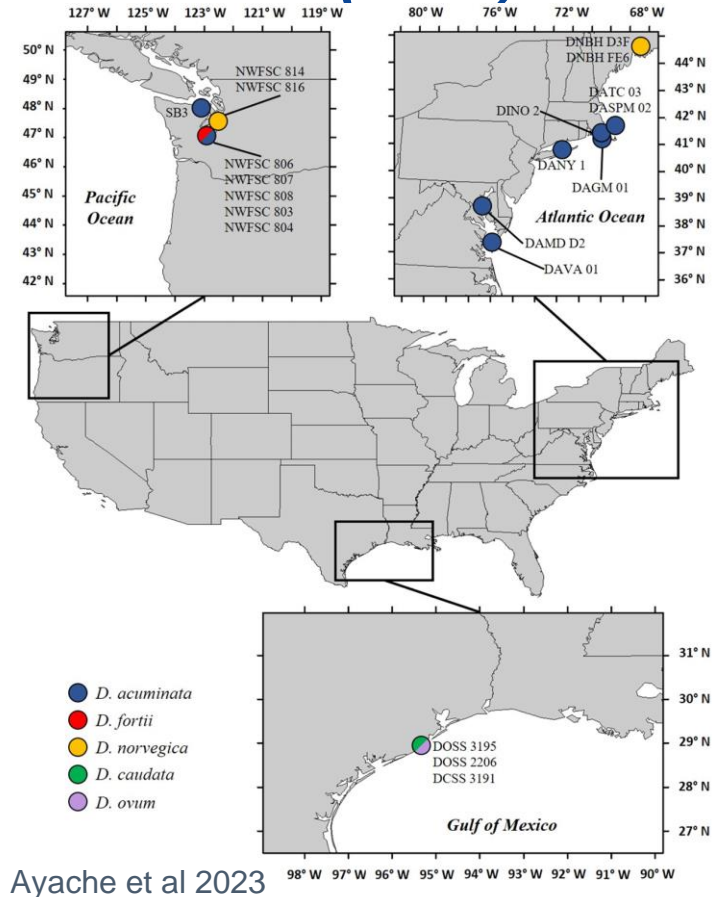
**Liquid Chromatography-
Mass Spectrometry**

- Technology widely applied in Washington
- Ongoing method improvement needed to address regional differences in toxin profiles

R2A: LC-MS for Diarrhetic Shellfish Toxins (DST)

ISSUE: Validated and approved methods needed for emerging toxin groups that pose a risk to health and commerce

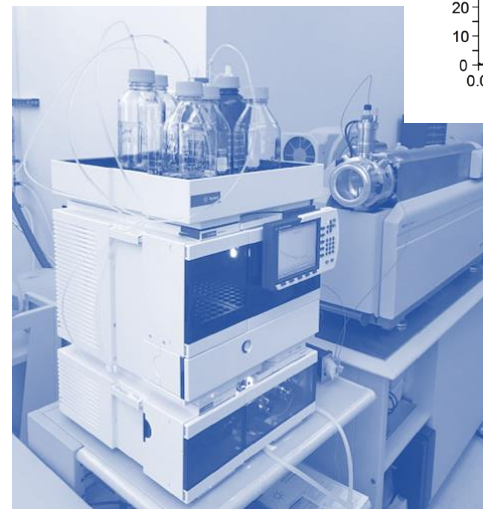
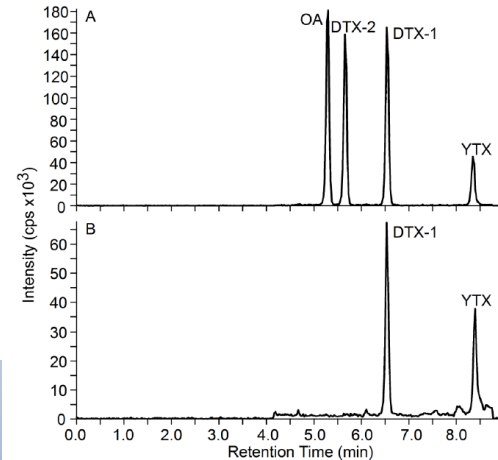
- DST-producing HABs likely expanding in intensity and geography
- Lipophilic toxins responsible for DSP emerges as U.S. issue (2008-11)
- Emerging knowledge of analytical detection provides opportunity to bring best in class detection to regulators



Ayache et al 2023

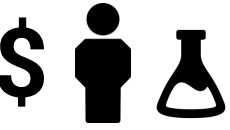
R2A: LC-MS for Diarrhetic Shellfish Toxins (DST)

- WHAT IS IT?
 - Liquid Chromatography-Mass Spectrometry
 - highly technical, specific equipment
 - chemical detection to elucidate & quantitate chemical structures
 - unambiguous ID of known chemical structures





2008-2010 - NCCOS Charleston and Int'l partners develop LC-MS-based DST method



2011-2015 - [MERHAB](#) / NCCOS Charleston analysis of aquaculture samples from New York using LC-MS
 SUNY Stony Brook, New York Dept Environ Conservation
 initial U.S. **development** and application of LC-MS
 assessment of PPI bioassay as alternative



2018-2022 - [MERHAB](#) / NCCOS Charleston optimized & evaluated EU harmonized method performance characteristics for determination of marine DST toxins by LC-MS
 -improved sample prep & LC-MS method w/ Washington Dept Health, FDA ORD
 alkaline v. acidic solvents, calibration matrix issues identified and resolved



2015 - NCCOS Charleston participates in European Union harmonised protocol **validation** study for determination of lipophilic Marine Biotoxins in Molluscs by LC-MS with Netherlands Institute for Food Safety



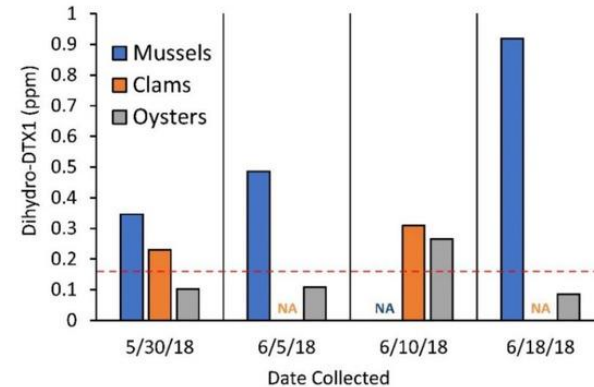
2015 - Washington Dept Health implements EU Harmonized method, because 2017 National Shellfish Sanitation Program method challenging to implement

- approved method does not represent regional needs (species, technology)
- more than 500 samples in excess of regulatory limit with some harvest areas closed for weeks and others for months to years.



2017-2019 - [PCMHAB](#) / Expanding ISSC Validated Options for Monitoring DSP Toxins

- evaluation of 3 toxin detection methods: lateral flow immunoassay, phosphatase inhibition assay, and LC-MS
- identification of dihydro-DTX1
- LC-MS method adopted into Nat'l Shellfish Sanitation Program for analyzing clams

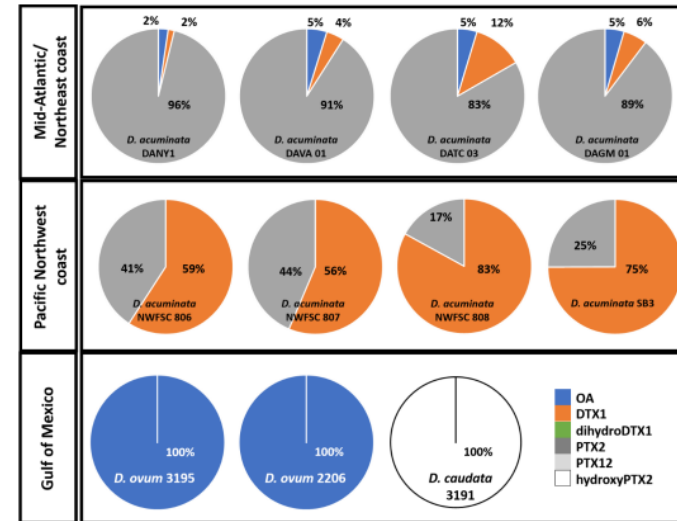


Deeds *et al* Toxins (2020)



2023 - PCMHAB / Developing harmonized approaches to quantify and monitor DSP toxins in shellfish tissue

- Expand to include blue mussels (gold standard)



regional differences in *Dinophysis* toxin composition, [Ayache et al 2023](#)

Lessons Learned

- Technical challenges associated with inaugural launch of a U.S. regulatory method based on chemical detection of HAB toxins.
- High cost of implementing advanced technologies may limit adoption. However, alternative DST methods (bioassays) are also challenging.
- "Final" products often revert back to research & development upon further understanding of the environment.
- The R2A process has yielded advanced knowledge of the previously unknown impact of DSTs across the U.S., resulting in methods applied in regulatory settings.

Overview

| QUALITY | RELEVANCE | PERFORMANCE |
|--|--|--|
| <ul style="list-style-type: none"> • DST testing by LC-MS is the first regulatory method in the U.S. to apply analytical techniques | <ul style="list-style-type: none"> • DST testing by State shellfish authorities using LC-MS has resulted in actionable information (harvest closures) | <ul style="list-style-type: none"> • Adapted to changing knowledge (new toxins), but required additional investment • Researchers have direct participation in regulatory adoption |

Questions about this case study?



| QUALITY | RELEVANCE | PERFORMANCE |
|---|---|--|
| <p>Toxin detection products are recognized as reliable and accurate through their validation, acceptance, and use</p> | <p>Internal and external investments deliver HAB toxin detection products that can eliminate poisonings</p> | <p>NCCOS has developed tools to achieve desired results and adapt to changing priorities</p> |

Though continuous improvement of our scientific products, NCCOS serves at a unique crossroads with the ability to advance the development of toxin detection tools to meet the needs of HAB communities with both resources and expertise.

Toxin detection science supports our understanding and measurement of HAB toxins with the goal to ultimately eliminate HAB poisonings.

Questions?



15 minute Break!

Return by 10:30AM



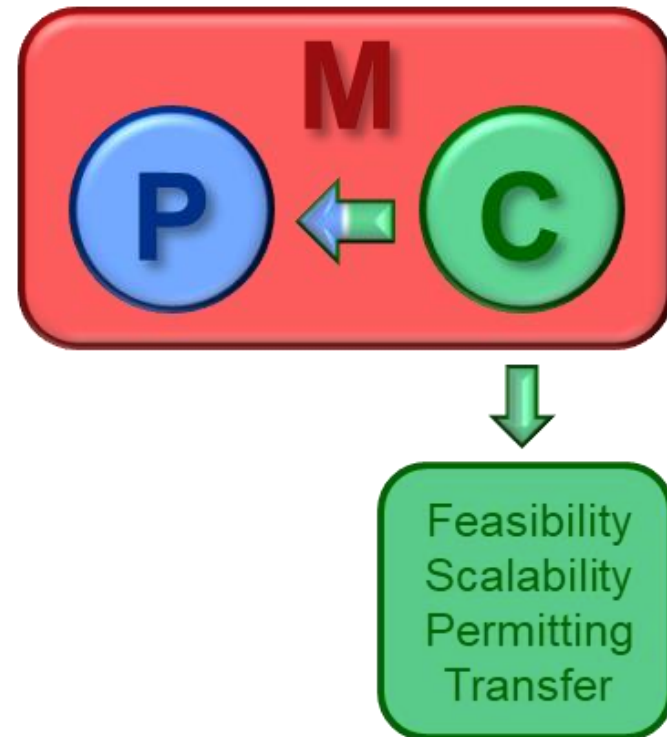
HAB Control

Three Phases to Solutions &
Adapting to Community Needs

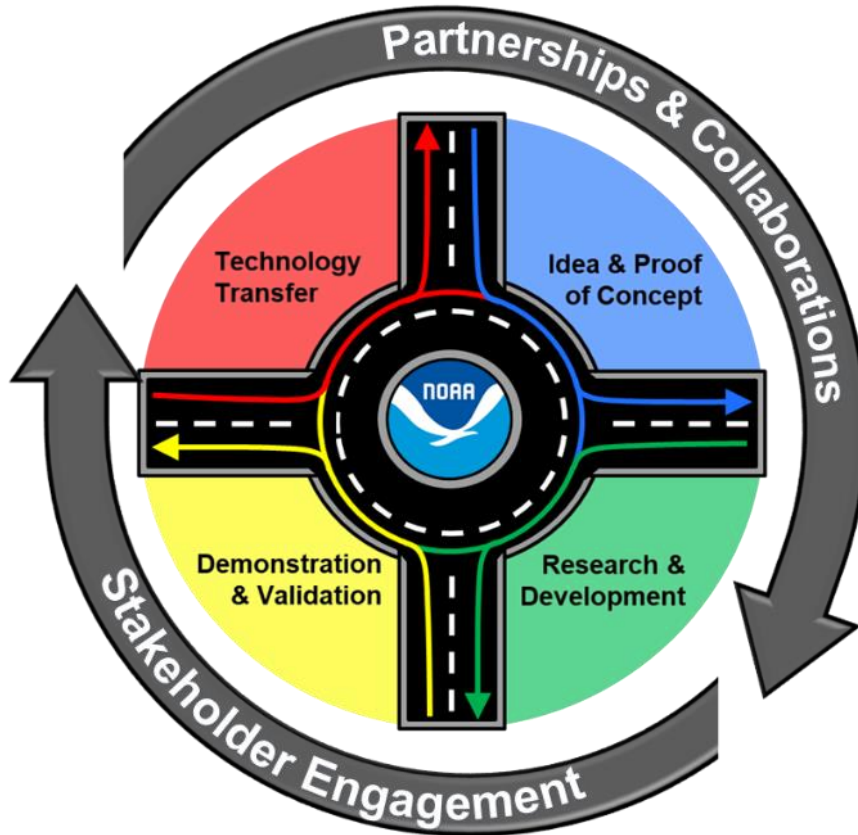
Kaytee Pokrzywinski (HAB-F), Felix Martinez (CRP), & Peter Moeller (HAB-MR)

HAB Prevention, Control, & Mitigation

- Prevention
 - Reduce incidence and extent before initiation
- Control
 - Kill, destroy, or remove cells and/or toxins
 - Limit algal growth
 - Preemptively manage HABs
- Mitigation
 - Limit delay or inhibit undesirable impacts on ecosystems and communities



NCCOS Approach to HAB Control



- Case studies for in-water cell/toxin control strategies
 - DinoSHIELD
 - Clay Flocculation
 - Nanobubble Ozone Technology (NBOT)
- Adapting to emerging needs
 - US HAB Control Technologies Incubator
 - US HAB Control Technologies Clearinghouse

HAB Control Process

4. Technology Transfer

- Transfer of proven technologies
- Whole lakes/large areas
- Licensing/permitting requirements



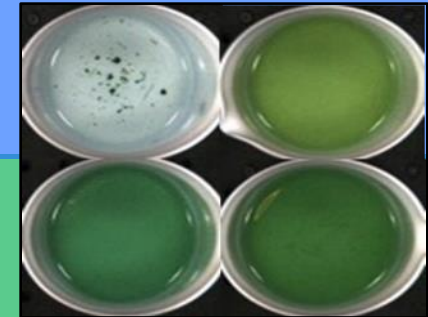
- Test and validate in field setting
- Confined areas
 - Mesocosms
 - Up to 1ac



3. Demonstration & Validation

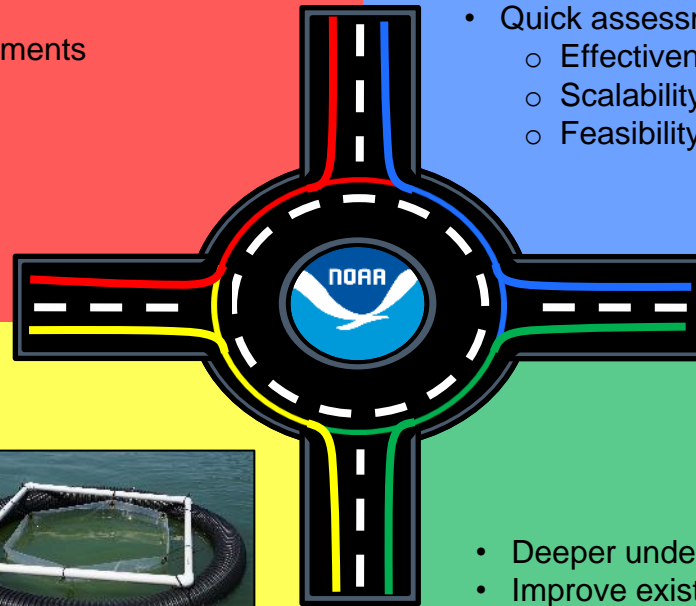
1. Idea & Proof of Concept

- Lab setting on cultures
- Quick assessment of novel technologies
 - Effectiveness
 - Scalability
 - Feasibility

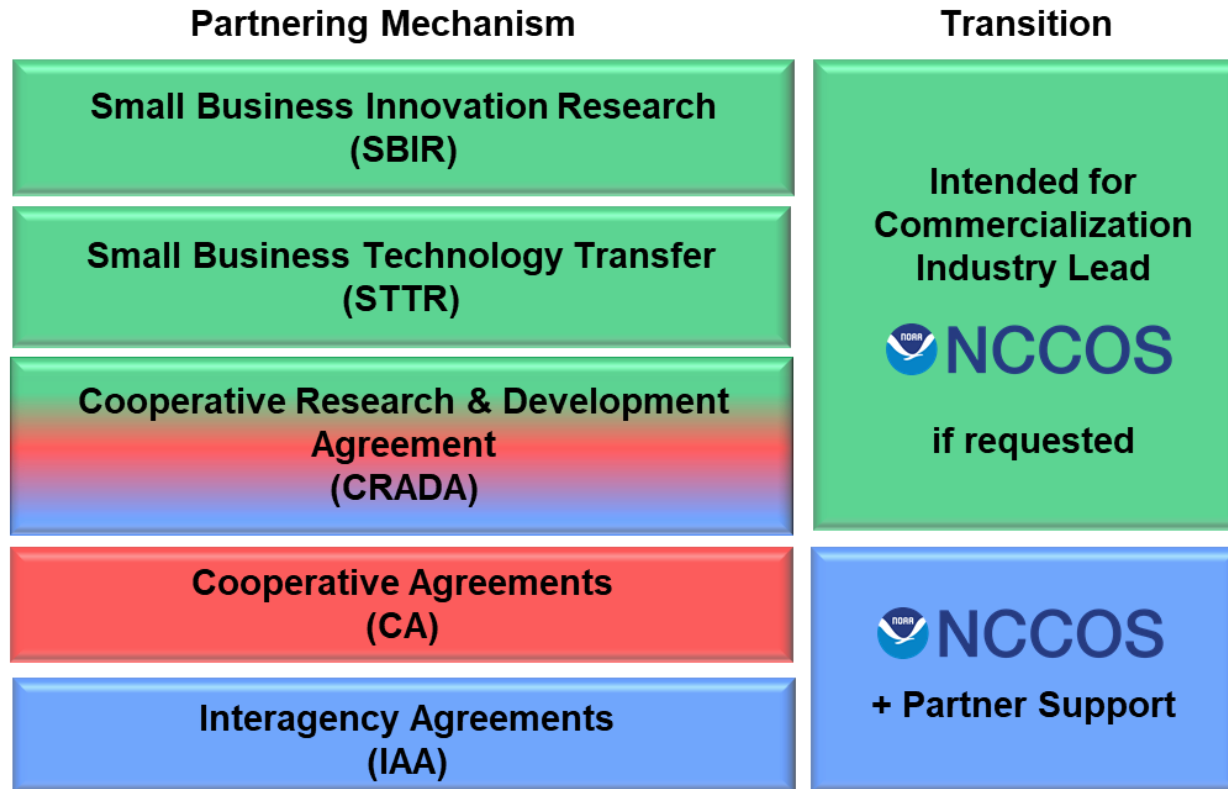


- Deeper understanding of new products
- Improve existing products
- Lab setting on cultures and collected site water

2. Research & Development

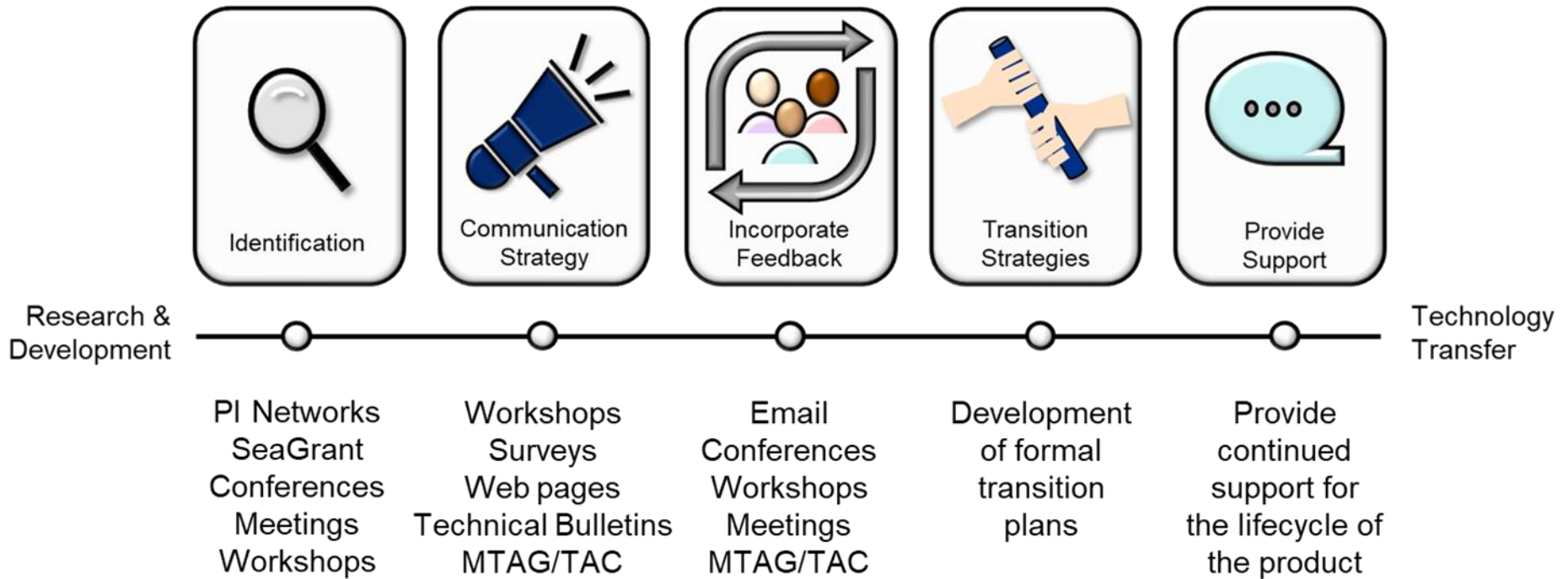


Collaborations & Partnerships



Industry & Non-profits, Academia, Resource Agencies
 & State/County Municipalities, Federal Agencies

Stakeholder Engagement Strategy



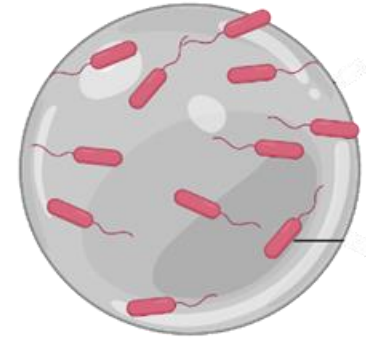
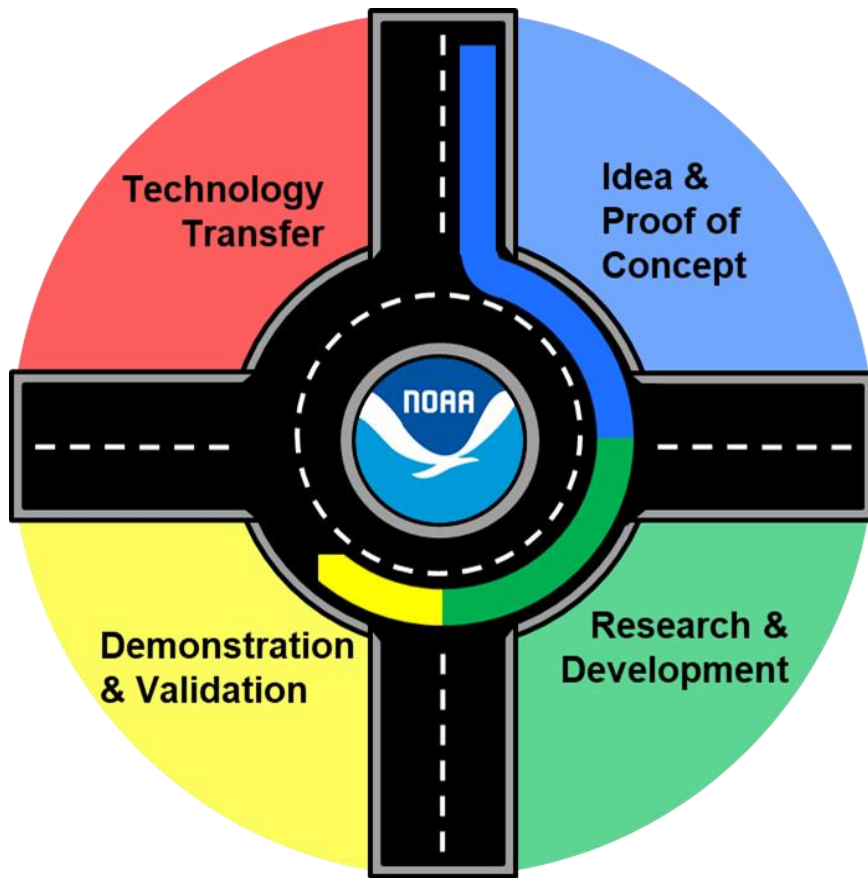
DinoSHIELD

Development, Testing, Validation

Project Lead: Dr. Kaytee Pokrzywinski (NCCOS)



DinoSHIELD



Duration: 12+ years

Funding: Primarily PCMHAB

Partnership: IAA & CA

Technology: Biological

Target: Dinoflagellates

Application: Marine (coastal)



What is DinoSHIELD?

A slow-release alginate hydrogel containing algicidal bacteria as 'mini *in situ* bioreactors'

Efficacy

- High specificity
- No effect on beneficial phytoplankton
- Fast response time (< 24hrs)

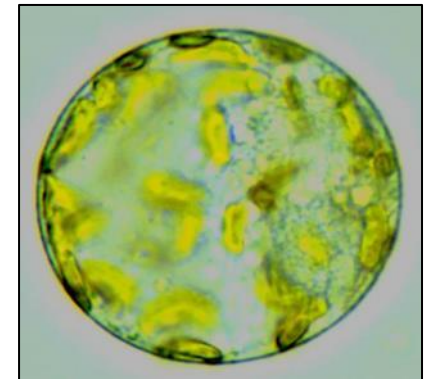
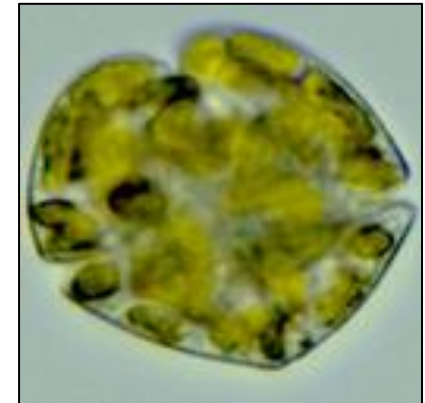
Safety

- *Shewanella* ubiquitous in DE & FL Gulf Coast
- *Shewanella* retained in DinoSHIELDS
- No effect on marine life

Application

- Easy to prepare and store
- Retreivable
- Non-toxic
- Biodegradable

Control

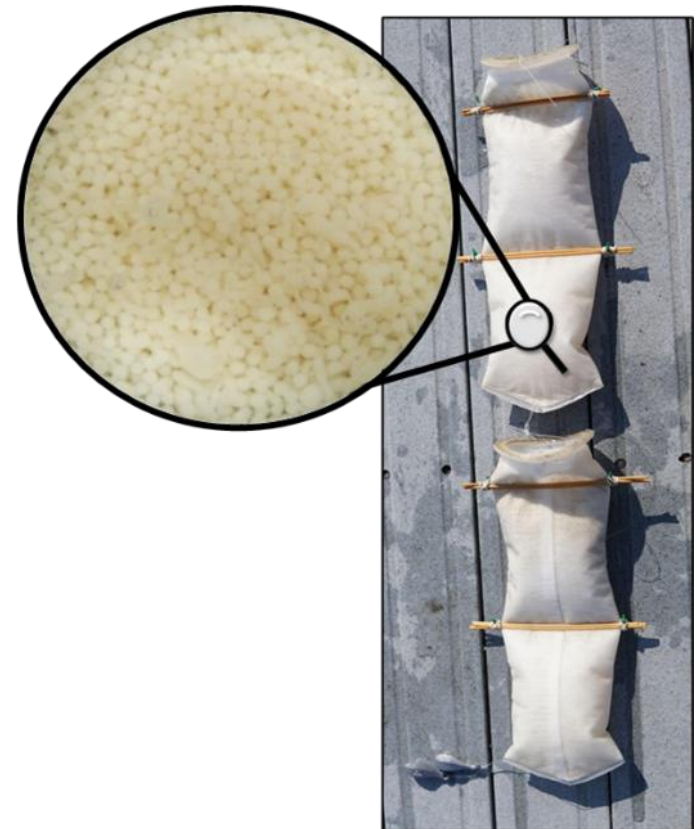


Treated

DinoSHIELD State of Science

- **Scaling-up in FL (Winter 2024)**
 - Deploy DinoSHIELDS during a red tide
 - 1 week exposure & 1 week post-treatment monitoring
 - Treat up to 1 acre (425x more volume than DE trial)
 - Confined using turbidity and bubble curtains

- **Preparing for the field**
 - Concentrate bacteria and/or raw algicide
 - Evaluate bacteria and matrix viability/stability
 - Re-evaluate deployment strategy
 - Working through site selection and local permitting



DinoSHIELD Stakeholder Engagement

- Developed regional technical bulletins
- Hosted workshop for DE Aquaculture Association
 - IRB approved pre/post-workshop surveys
- Planning to host FL workshop/survey series
 - Preparing animated videos
 - IRB approved pre/post-workshop surveys
- Also distribute via meetings, conferences and technical workshops
 - Annual TACs
 - US HAB, PICES, ICHA



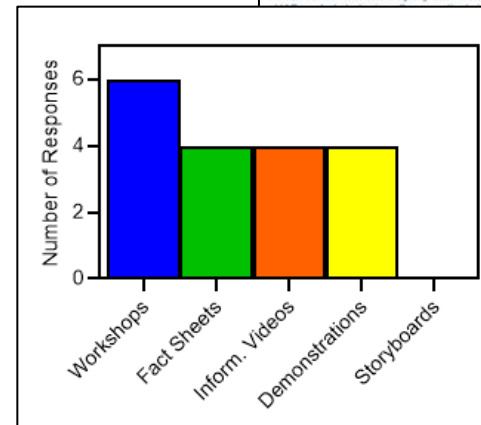
DinoSHIELD: A Natural Approach to Control Red Tides

WHY DINO SHIELD?
 Marine harmful algal blooms (HABs), sometimes referred to as red tides, are caused by microscopic algae that can produce toxins which are harmful to both humans and animals. Toxins produced by HABs can accumulate in shellfish tissue potentially leading to shellfish poisoning when consumed. The majority of available marine...

WHAT IS DINO SHIELD?
 DinoSHIELD is an emerging technology which aims to prevent and control HABs in marine waters, reducing the impact of HABs on coastal communities and economically important industries such as shellfisheries and tourism. DinoSHIELD technology relies on the slow release of an algicide naturally produced by a bacterium commonly found in coastal waters, including the Delaware Inland Bays. The bacteria are immobilized in a hydrogel system that can release the algicide while retaining the bacteria so that the algicide can be continuously delivered.

HOW IS DINO SHIELD USED?
 Following production of DinoSHIELD in the lab, the algicide-containing hydrogel beads are put into a mesh bag and suspended at various depths off of docks and other existing marine structures to ensure a consistent application rate across the target area. These mesh bags can be deployed for the prevention and control of marine HABs in ecosystems with chronic blooms. Following regulatory approval, DinoSHIELD can be used by state managers, shellfish growers, and other end-users to safely manage HABs in their coastal waterbodies.

1305 East West Hwy, Ste 8110
 Silver Spring, Maryland 20910
 240.533.0300 | dinoshield.nmfs.gov
[facebook.com/nccoscentral](https://www.facebook.com/nccoscentral) | www.instagram.com/nccoscentral



DinoSHIELD Stakeholder Engagement



"I was at the presentation last night on the DinoSHIELD technology under development... certain Shewanella species have been associated with potential for shellfish-borne illnesses... I'm sure this has already occurred to you, and probably the answer is as simple as your Shewanella being a different, non-pathogenic species..."

– Andrew Bell, DE Shellfish Standardization Officer

"Do you think you can get permits to deploy DinoShield in natural waters? Is it affordable? Might it work on Rust Tide? Do you want research partners? I think I can get grant funding and have investigators and industry partners lined up."

**Bob Rheault, Executive Director,
East Coast Shellfish Growers Association**

"...thanks for setting up this presentation. I have great interest in this subject..."

– Mark Casey, President of Delaware Cultured Seafood (he sent us a ppt full of questions)

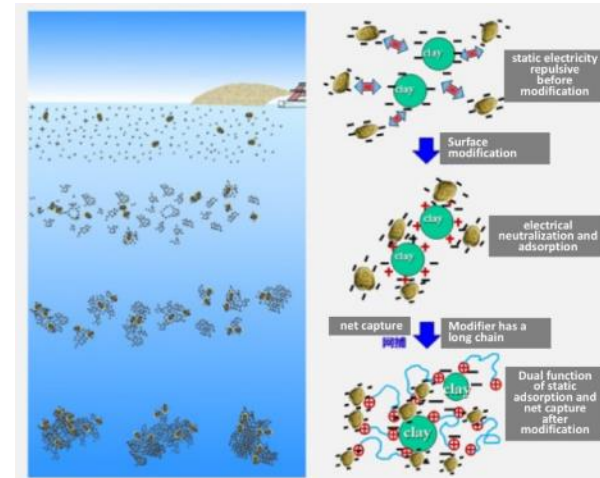
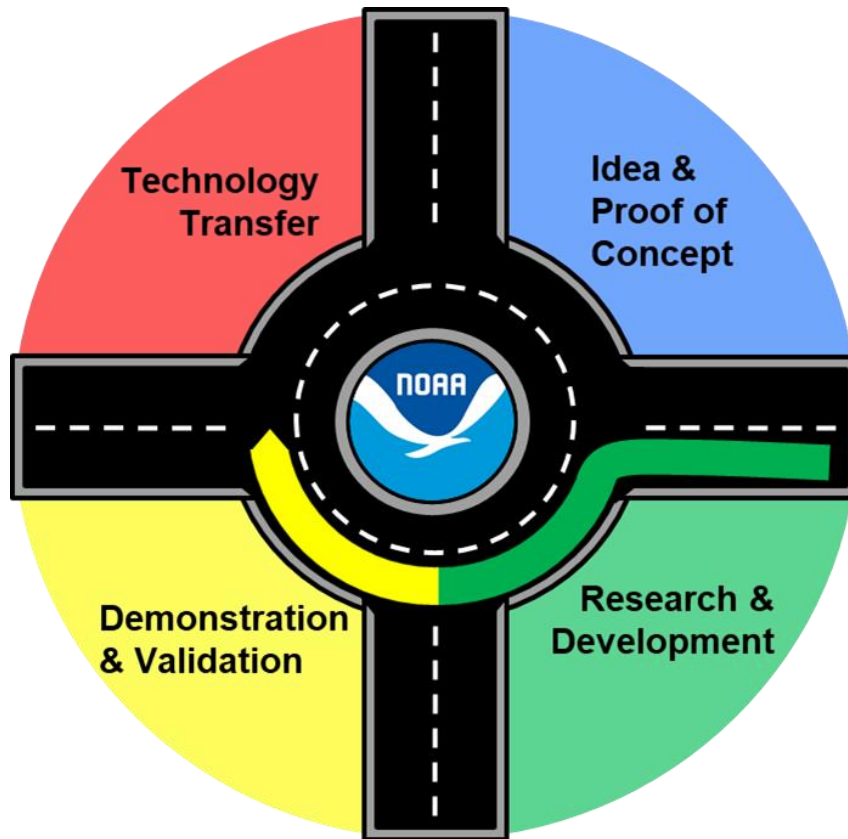


Clay Flocculation

Validation

Project Lead: Dr. Don Anderson
(Woods Hole Oceanographic Institution)

Clay Flocculation



Duration: 5 year award

Funding: PCMHAB*

Partnership: CA

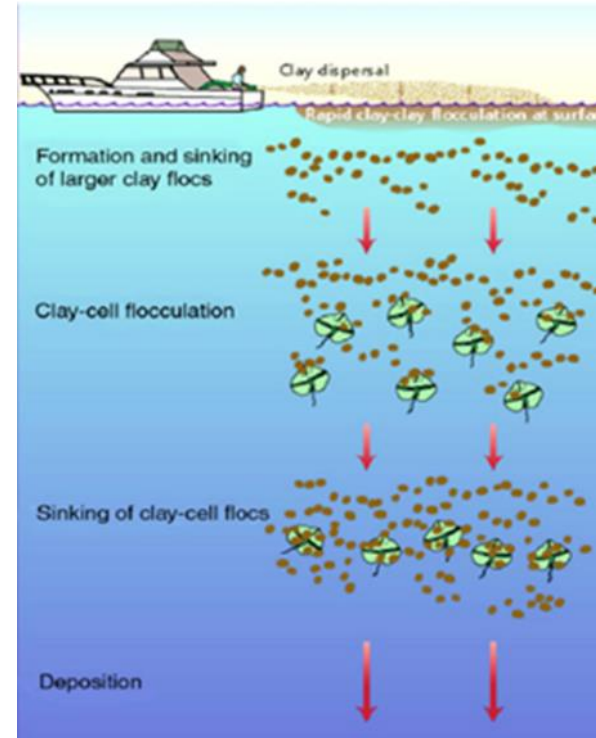
Technology: Physicochemical

Target: Dinoflagellates

Application: Marine (coastal)

What Is Clay Flocculation?

- Through natural electrical charges clay binds to algal cells and causes them to sink to the bottom
- Clay compounds need to be evaluated in order to:
 - Confirm effectiveness/safety on US ecosystems
 - Obtain federal/state regulatory approvals



Clay dispersal and flocculation, leading to removal of HAB cells. Credit D. Anderson (WHOI) adapted from [Sengo et al., 2005](#).

Clay Flocculation State of Science

- Status:
 - Lab and mesocosms trials successful
 - Original clay formulation removes cells but not extracellular toxin
- Next steps:
 - Large scale (1 acre) trials pending
 - Testing new clay formulations to enhance toxin removal (Mote/FL-RI funded)



Chinese vessels spraying clay. Credit D. Anderson, WHOI



Pilot study of clay dispersal conducted at the Sarasota Outboard Club canal, Sarasota, FL. Credit D. Anderson, WHOI

Clay Flocculation Stakeholder Engagement

- Socioeconomic value
 - Cost-benefit analysis
 - Discrete choice surveys
- Public perception
 - Journalism
 - Open educational public meetings



Experimental application of clay flocculation slurry during a small enclosure trial in Sarasota. Note the temporary coloration of the water at the time of application. Credit: Mote Marine Lab.



COLLEGE of
CHARLESTON



N_{ano} B_{ubble} O_{zone} T_{echnology}

Development, Improvement, Validation

Project Lead: Dr. Peter Moeller (NCCOS)

CRADA

Other Key Collaborators: (Academia) AMURI, CoC,
USC; (Agencies) EPA, USACE, OHDEP, FLDEP;
(Industry) Commercial Partners, CRADA Partners

NBOT CRADA & Independent Quality Testing



Develop for commercial use, ozone impregnated nano-bubble technology to address water safety & security issues including:

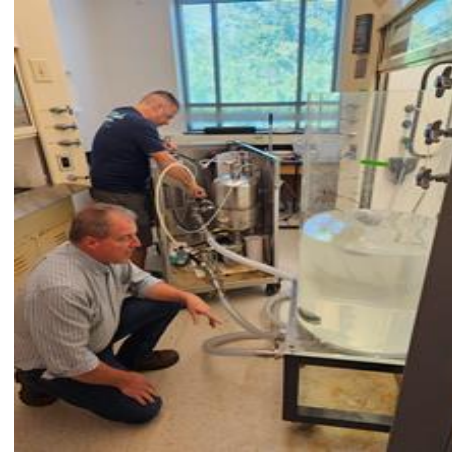
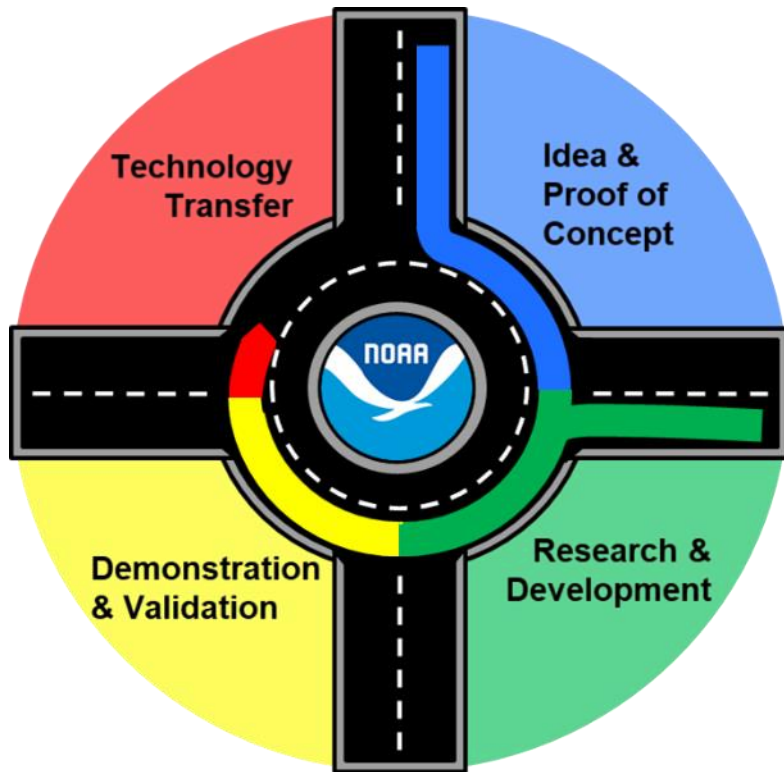
- Algae mitigation/remediation.
- Toxin destruction and elimination.

The Lake Superior Research Institute's Great Waters Research Collaborative aims to provide unbiased and independent data to accelerate the development of technologies with potential to prevent the introduction and/or control the spread of non-indigenous organisms.

The overall conclusion from the biological effectiveness testing with NBOT-2.5HP is that the system is highly effective at controlling concentrations of algae, bacteria and motile zooplankton.

Determination of the chronic residual toxicity of NBOT 2.5-HP treated water to non-target organisms showed that in there was no statistically significant effects on any of the three organism types tested.

NanoBubbleOzoneTechnology



Duration: 7+ years

Funding: CRADA & NCCOS Base

Partnership: CRADA & LSRI

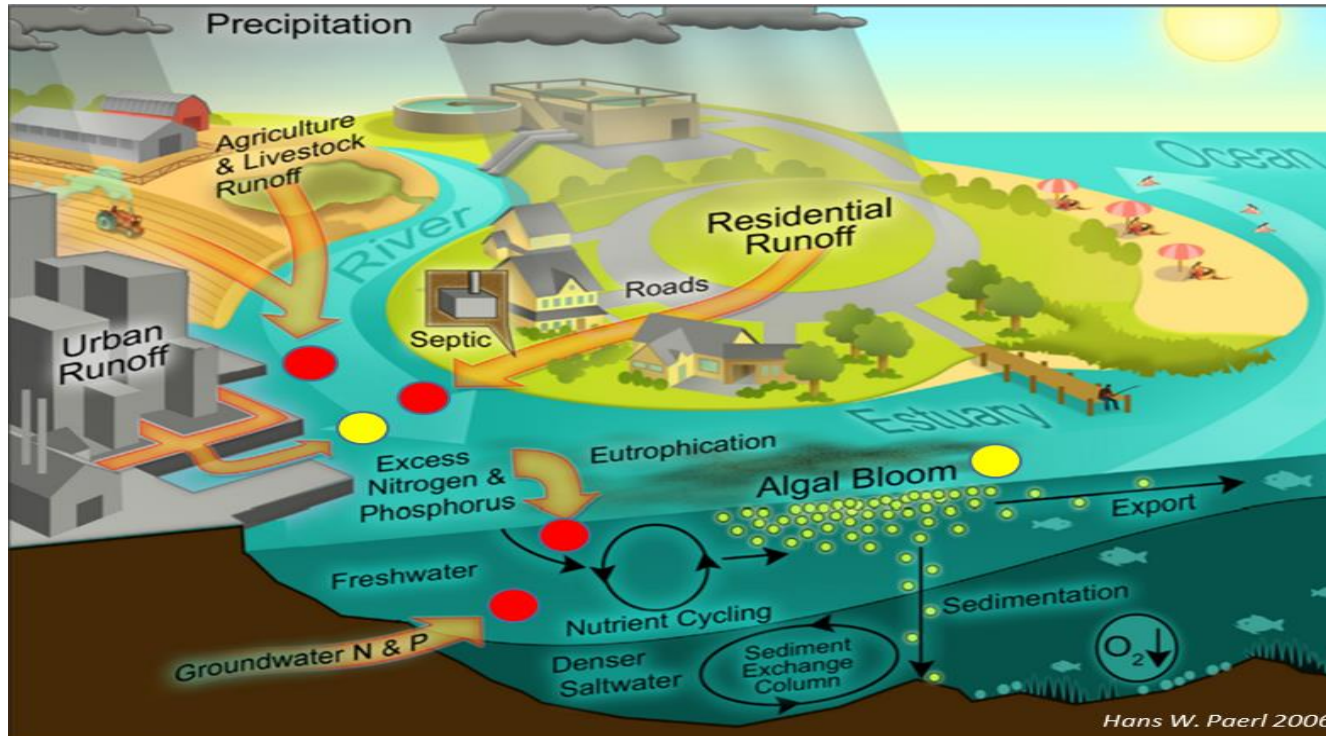
Technology: Physicochemical

Target: All HABs and Toxin

Application: Marine and Freshwater

What Is NBOT?

Ozone Impregnated Nano-bubble Technology (NBOT) - Mitigating HABS, Toxins, Contaminants, Nutrients and Their Impacts : A Novel, Green Approach to Water Safety and Security



Technology Combines Four Unique Attributes

1. Scalable
2. Configurable
3. Self Contained/Controllable
4. No Legacy Residues

Complete Approach to Mitigation/Remediation

1. Destroys Microbes
2. Destroys Toxins/Contaminants
3. Removes Nutrients
4. Removes Heavy Metals

And It's
GREEN!

NBOT Research Focuses on the Entire Harmful Cycle at Multiple Points

● Developed

● Under development

NBOT State of Science



Lake Newport: 1.5 Miles Long, 60-65 Acres

Responsible Mitigation/Control/Prevention
Main Requirements

1. Treats HABS & Microbial Consortia (biology)
2. Treats Toxins and Contaminants (chemistry)
3. Reduces/Removes Nutrients and Metals
4. Maintains Environmental Stewardship

Data and results generated from Lake Newport NBOT treatment has led to ozone impregnated nano bubble technology being transitioned to and applied in waste-, drinking-, and industrial effluent water treatments.

NBOT Tech Transfer & Stakeholder Engagement

- Data and results generated by CRADA partnership is collated and interpreted for industrial partners to market/transition developed technology for commercial applications.
- All mesocosm or open water trials are coordinated with local communities prior to operation. Resulting journal articles, technical reports and videos are provided to industrial partners for dissemination to the public on demand.



Before and after Cape Coral NBOT mesocosm trial 2019

Case Studies Summary

- NCCOS HAB control strategies are targeted for
 - Specificity
 - Scalability
 - Environmental safety & sustainability
- Several products in various stages of development that may serve as **environmentally friendly means** to effectively control HABs
 - DinoSHIELD and Clay - dinoflagellates
 - NBOT - cyanobacteria
- Capitalize on various partnership strategies to advance control science & **ensure products meet needs, budgets, and skill levels**
 - CRADA - Partner transfer & engagement
 - CA & IAA - NCCOS transfer & engagement



Challenges to Control Science

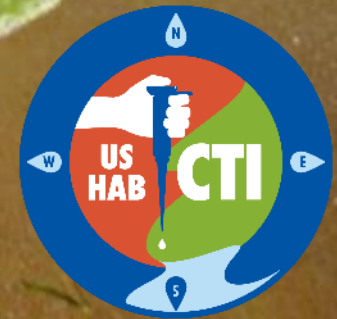
- No one product will treat everything
- Require a basic understanding of target species and ecosystem
- Need to assess environmental and human health impacts
- **Need seed funding for proof of concept studies**
 - Feasibility
 - Effectiveness
 - Scalability
- **Unique aspects that make transition challenging**
 - Community perception
 - Regulatory requirements/approval processes (Federal)
 - Permitting (State/local authorities) - research & operational scales
 - Commercialization (CRADA)



US HAB-Control Technologies Incubator and Clearinghouse

New Ideas/Proof of Concept and Transition

Project Lead: Dr. Allen Place (UMCES)



US HAB-CTI & Clearinghouse

CA with UMCES & Mote Marine Lab (\$7.5M, 5+ yr)

Incubator (\$5M)

- Annual competition
 - Up to 1 yr
 - \$250K max/project
 - non-renewable awards
- Quick assessment of novel technologies for
 - Effectiveness
 - Scalability
 - Feasibility

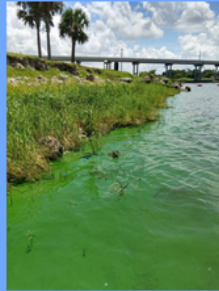
Clearinghouse

- Permitting/Regulatory Requirements
 - Federal/state specific
- Resource list
 - Agency/private contacts
- Available technologies
 - By region, species, habitat, etc.

HAB Control Summary

Objective

- Develop nationally relevant products to address regional problems
- Flexibility to transfer strategies to other regions as problems emerge
- Transition strategies for operational use



Key Users & Stakeholders

- Agencies (e.g. resource managers, drinking and wastewater operators)
- Industry (e.g. aquaculture, marina operators, industrial waste streams)
- Private (e.g. HOAs, NGOs with interest in improving surface water quality)

Key Partners

- NCCOS Internal expertise (SDI, CRP)
- Federal, state, and local agencies
- Academia
- Industry
- Private Sector



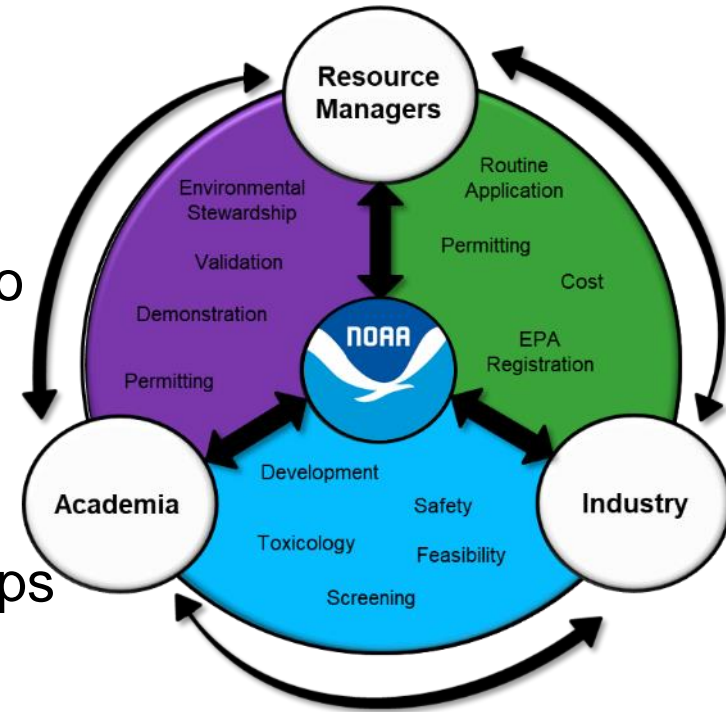
Synopsis & Next Steps

- Provide environmentally sustainable strategies for end users to safely incorporate into routine management practices



Takeaways

- Control is arguably the most challenging area in the HAB sciences
- Control science is often iterative working to improve on products or delivery vehicles
 - Reduce environmental impacts
 - Reduce cost
 - Improve effectiveness
- Adapt to community needs/filling in the gaps
 - Providing structure and direction
 - Driving control science (intramural & extramural)
 - Coupling government, academia and industry needs
 - Reduce duplication
 - Facilitate collaboration



LUNCH!

12:00 – 1:30PM



R2X Stakeholder Panelist Discussion

Closed Session



15 minute Break!

Return by 3:25PM



Public Communication and Societal Acceptance Stakeholder Discussion

Closed Session



Executive Session

Review Panel only

Panel Reception to follow at Silver Branch Brewing

5:30PM

(8401 Colesville Rd #150, Silver Spring, MD 20910)



NCCOS Annual Science Review: Harmful Algal Blooms and Hypoxia Program

Silver Spring, Maryland
28 - 30 November, 2023

Review Website: [NCCOS HABs and Hypoxia Program Review](#)



WELCOME BACK!

Margo Schulze-Haugen, NCCOS Deputy Director



Reporting and Submission Overview

Margo Schulze-Haugen, NCCOS Deputy Director
Lonnie Gonsalves, SDI Division Director
Shelby Butz, Review Coordinator



Panel Discussion and Drafting Initial Recommendations

Closed Session



Review Panel Presentation to NCCOS Leadership

Review Panel Members



Thank You and Final Remarks

Sean Corson, NCCOS Director

