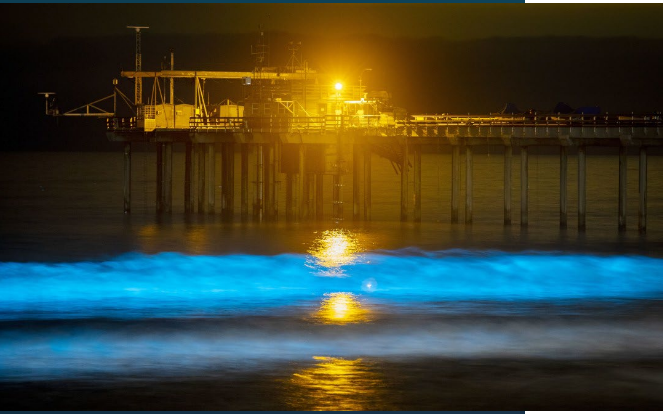
IOC-FAO Intergovernmental Panel on Harmful Algae Blooms (IPHAB)

The Next Decade of GlobalHAB: 2026-2035



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Global HAB
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SCOR
Scientific Committee on Oceanic Research

GlobalHAB

Global Harmful Algal Blooms

Science and Implementation Plan

An International Programme Sponsored by the Scientific Committee on Oceanic Research (SCOR) and the Intergovernmental Oceanographic Commission (IOC) of UNESCO

Edited by: C. Anderson, E. Berdalet, D. Clarke, P. Hess, A. Li, L. Mangialajo, J. Mardones, S. Nascimento, M. Olofsson, H. Raymond, R. Siano, M. Suddleson, and A. Yniguez

SCRIPPS INSTITUTION OF OCEANOGRAPHY
UC San Diego

Presented by Clarissa Anderson, Ph.D., GlobalHAB Chair
Scripps Institution of Oceanography, University of California San Diego

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What is GlobalHAB?

The overall **Goal of GlobalHAB is** to improve understanding and prediction of Harmful Algal Blooms (HABs) in aquatic ecosystems, and management and mitigation of their impacts.

The **Mission of** GlobalHAB includes the following elements:

a) Foster international coordination and cooperative research to address the scientific and societal challenges of HABs, including the environmental, human health and economic impacts, in a rapidly changing world.

b) Consolidate linkages with broader scientific fields and other regional and international initiatives relevant to HABs.

c) Foster the development and adoption of advanced and cost-effective technologies.

d) Promote training, capacity building and communication of HAB research to society.

d) Serve as a liaison and promoter between the scientific community, stakeholders and policy makers, informing science-based decision-making.

- Addresses the contemporary scientific and societal challenges of Harmful Algal Bloom (HABs)
- Adopts a multidisciplinary approach through the evaluation and application of new advanced technologies
- Conducts training and capacity building
- Promotes dissemination of new community-driven information and best practices
- Co-designs for local, regional, national, and global decision-making on all topics pertaining to HABs

GlobalHAB Science and Implementation Plan: 2017-2026

Led by Elisa Berdalet, former GlobalHAB Chair

1) Biodiversity and Biogeography
2) Adaptive Strategies
3) Toxins
4) Nutrients and Eutrophication
5) Freshwater and Cyanobacterial HABs from Marine to Freshwater Systems
6) Benthic HABs
7) HABs and Marine Aquaculture
8) The Comparative Approach
9) Observation, Modeling and Prediction
10) HABs and Human and Animal Health
11) Economy
12 Climate Change and HABs
13) *Sargassum* beachings

GlobalHAB Science and Implementation Plan: 2017-2026

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The Next Decade of GlobalHAB: 2026-2035

Led by Clarissa Anderson

"Wicked Problems" as Cross-Cutting Themes

- Emerging HABs
- Global climate variability and change
- Multiple interacting stressors with synergistic influence on microalgal physiology
- Expanding cyanobacterial blooms
- Often unpredictable human dimension driven by local/regional community responses to HABs harbinger of a new era of global HAB research, coordination, and critical resource leveraging if we are to develop solutions.

The Next Decade of GlobalHAB: 2026-2035

"Wicked Problems" as Cross-Cutting Themes

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Key questions buttressing specific goals & tasks:

1) How does global change cascade through or overlie the immediate science questions?
2) How do we forecast HABs in a changing climate when baselines are also changing and interacting with multiple stressor trends?
3) What techniques will improve our ability to predict both blooms and impacts throughout food webs or directly on human health?
4) Can we identify possible tipping points or nonlinear change points in relevant ecosystems?
5) How will new research findings be linked to broad societal drivers surrounding geoengineering solutions to climate change, e.g., marine carbon dioxide removal and renewable offshore wind energy?

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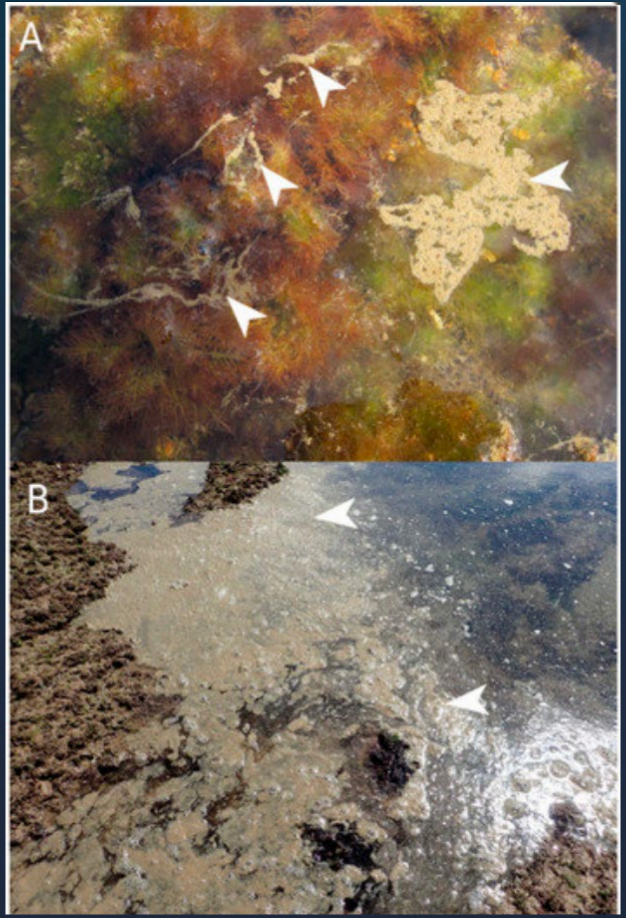
Goal 1. Emerging threats: Characterize invasion ecology and changing biogeography of potential HAB species

Ostreopsis cf. *ovata* in the Bay of Biscay (Spanish and French Basque countries)
Chomerat et al. 2022



TASKS & OUTCOMES

- Global diversity baselines
- Methods for collecting and analyzing aerosols
- Global baselines/recommendations for cyanobacterial blooms and their toxins
- IOC training courses emphasizing classical taxonomic identification
- eDNA-based methods

1) Consolidation of a baseline of HAB species distributions based on morphological and new genomic information at local, regional, and global scales
2) Improved knowledge on the information that can be delivered by eDNA-based methods relative to light microscope
3) A larger, coordinated community of experts on microalgal taxonomy, supporting HAB monitoring efforts worldwide
4) Effective implementation of policies protecting the environment and preventing expansion of HABs.

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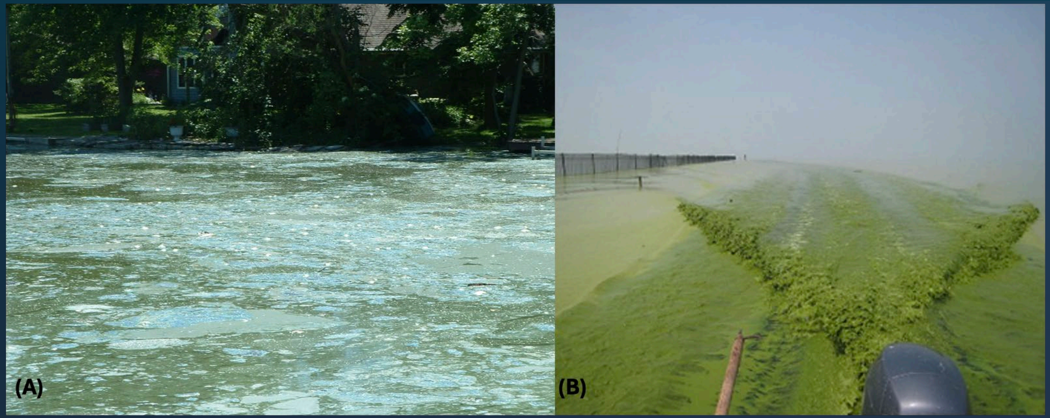
Goal 2. Food Security and Human Health:

a. Codify methodologies to understand the threat and impacts to fisheries and aquaculture posed by HABs



(A) Harmful algal bloom and resulting fish kill on Grand Lake St. Mary's, Ohio, USA. Microcystins (multiple variants), saxitoxins, cylindrospermopsins, anatoxin-a, and euglenophycin
(B) Recurrent harmful algal bloom on the third largest lake in China, Taihu.

TASKS & OUTCOMES

- "Communities of Practice" -- recurring and emerging HABs threatening aquaculture sustainability
- Best practices for mitigating fish-killing blooms
- Socioeconomic impacts on commercial, subsistence, and recreational fisheries
- Targeted engagement strategies with industry and fisheries managers
- Risk assessment of seafood contamination and impact on economic supply chains

1) Strengthened HAB monitoring frameworks in aquaculture and fisheries sectors
2) Recommendations to reduce economic losses due to HAB-related impacts
3) Enhanced communication channels between scientists, regulators, industries and communities

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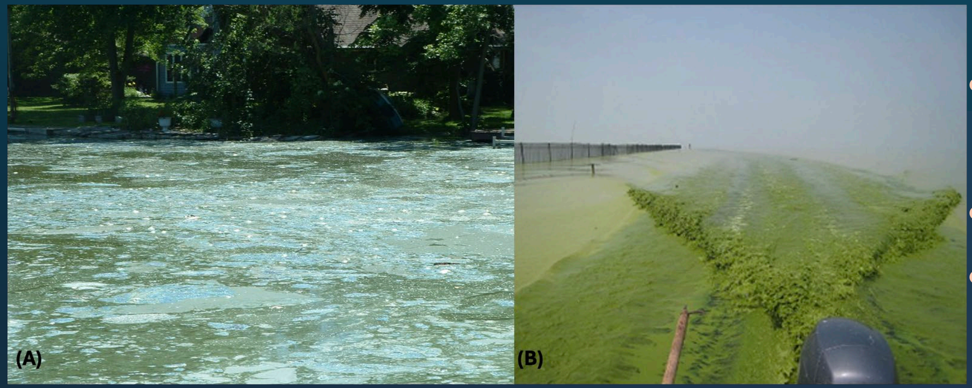
Goal 2. Food Security and Human Health:

b. Freshwater HAB Impacts on Human, Animal, and Ecosystem Health



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TASKS & OUTCOMES

- Global freshwater HAB satellite data center modeled after U.S. CyAN program
- Exposure studies for development of LD50s, TDI, and NOAELs
- Evaluation of different types of toxin exposure of standardized sampling methodologies for freshwater benthic HABs
- Effective source water HAB control technologies
- Inform and train medical professionals
- Global guidelines for cyanobacterial toxin accumulation

1) Inform local decision making with access to processed satellite data
2) Global trends of freshwater HABs driven by eutrophication and climate change
3) Occurrence of freshwater benthic HABs and risks to humans
4) Information for policy makers
5) Guidelines for cyanobacterial toxins for safe food consumption
6) Improved public health protection

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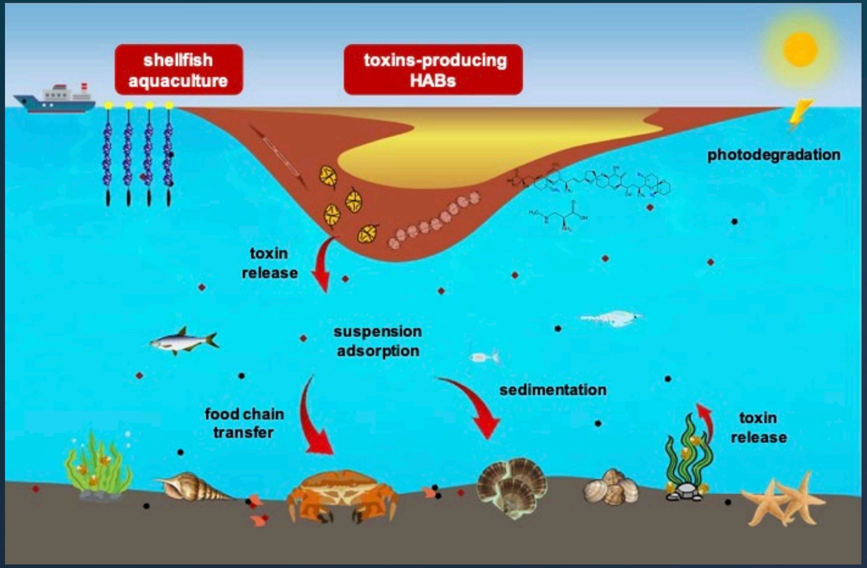
Goal 3. Food Web Complexity influencing HAB Dynamics

a. Use new methodologies in genomics to define the role of tropho-dynamics in structuring HAB occurrence, frequency, intensity, and food web impacts



TASKS & OUTCOMES

- Tools & models of mixotrophs, food webs, and pathways
- Microalgal community interactions for predicting HABs
- Benthic-plankton interactions
- Diversity of toxin accumulation, biomagnification, and trophic Transfer and transformation of toxins in food webs
- Food web complexity -/lab/mesocosm/depuration experiments
- Interactions between algal species & bacteria + viruses
- Metagenomic advances

1) Experimental guidelines & predictive models for HAB formation/persistence/food web impacts
2) Information on toxin transfer pathways across ecosystems and their ecological consequences
3) Stronger integration of field, laboratory, and modeling approaches for assessing HAB/food web interactions
4) Workshop to share findings, discuss methods, foster a community of practice around metagenomic advances

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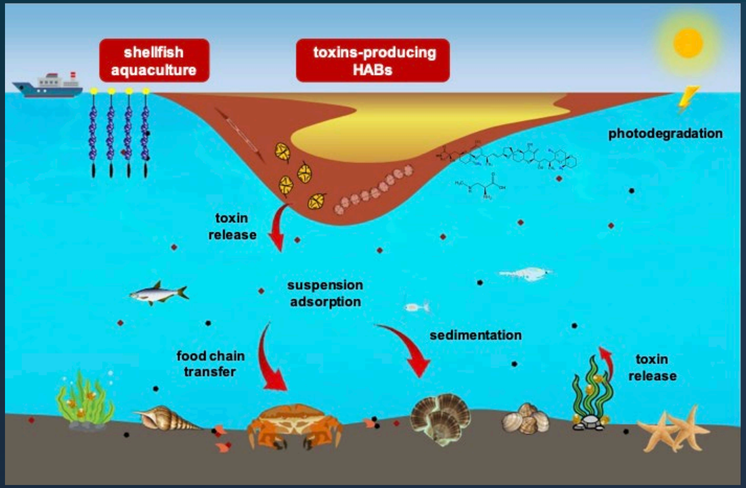
Goal 3. Food Web Complexity influencing HAB Dynamics

b. Apply improved detection techniques and experimental approaches to move towards a predictive understanding of regulations on toxin production phases, mechanisms of harm, and reverberating effects in food webs

TASKS & OUTCOMES



- Dissolved and aerosolized toxins - behaviors in seawater and air media
- Sensitive /rapid detection methods for early warning of toxins
- Workshops --sensitive and quick monitoring methods of toxins
- Toxicological mechanisms of fish and shellfish-harmful compounds
- Chemical ecology effects of dissolved toxins
- Genetic basis for toxin production/biosynthesis
- Purify/obtain reference standards of toxins
- Shared knowledge of genetic basis for toxin production

1) Enhanced detection methods for tracking toxin impacts on fisheries and marine organisms
2) Enhanced early-warning systems for HABs through rapid detection techniques
3) Establishment of databases for dissolved toxins in coastal regions with frequent occurrence of HABs
4) Development of portable and quick detection methods for dissolved toxins in seawater
5) Elucidation of the compounds that kill fish and shellfish in the events of HABs
6) Understanding of the cascading impacts of dissolved toxins on regional or global ecosystems
7) Promotion for application of multi-omics approaches to disclose the biosynthesis pathways of toxins
8) Advancements in molecular and genetic understanding of toxin biosynthesis in HAB species

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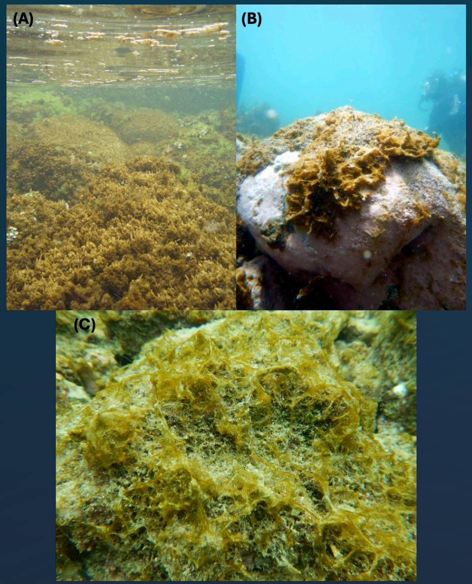
Goal 4. Benthic HABs: Ecological studies including species ecophysiology, biotic interactions, responses to nutrient enrichment, to a changing climate, and to habitat destruction, besides bloom impacts on ecosystem and human health.



TASKS & OUTCOMES

- Methodologies to quantify benthic dinoflagellates -- macro-organism community-based indicators as early warning signals
- Workshops for early warning signals of bHABs
- Monitoring/regulations/mitigation actions at the ecosystem level
- Best practices for rapid/cost-efficient tools to monitor benthic HABs
- Molecular techniques to monitor *Gambierdiscus* in Ciguatera endemic areas as an early warning system for Ciguatera

1) Improved quantification methods for benthic HAB species, and therefore risk assessment capabilities
2) List of indicators based on tipping points of ecosystem change - early warning signals of bHABs
3) Proposed monitoring/regulations/mitigation actions decrease the risk of intoxications
4) A newly established baseline of knowledge on species distributions (preferably based on molecular methods) and impacts
5) Improved understanding of factors that trigger benthic HABs in different systems worldwide.
6) A unified protocol of practices for medical doctors on how to treat the symptoms of ciguatera.

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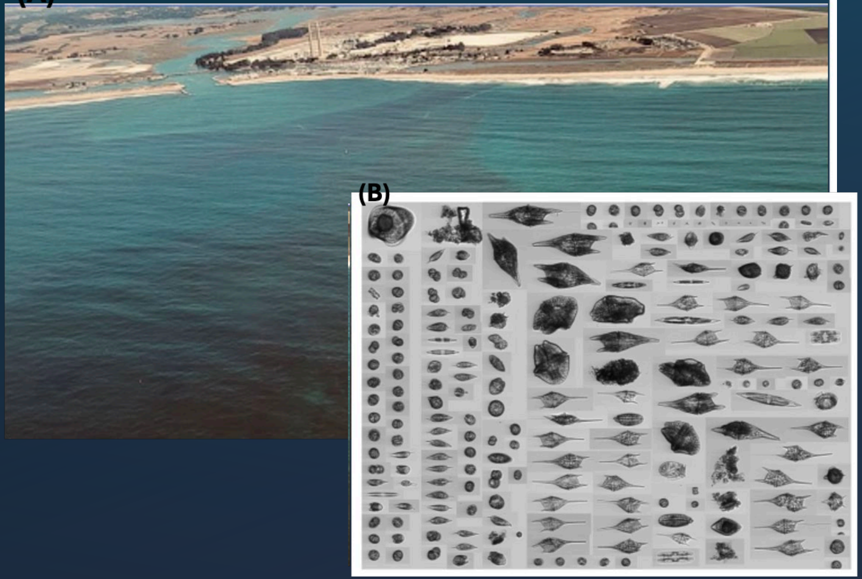
Goal 5. Automated HAB Detection and Prediction: Apply advanced remote sensing, machine-learning modeling techniques, and in situ observing to HAB detection, prediction, and operational forecasting for mitigation and spatial/temporal awareness of bloom transport

(A) (B)



TASKS & OUTCOMES

- Democratic nature of satellite data sets for capacity building
- Collaborate with IOCCG & NASA/ESA on guidelines for validation where expensive monitoring programs are not possible
- Open-source algorithms for HAB detection
- Focus on blended RS/modeling approaches
- Co-design early warning products with end-users
- *In situ* biosensors, IFCBs, AUV's, ASV's, UAV's + advanced/open source tech, e.g. IFCB, PlanktoScope, Flowcam, Cytosens
- Focus on mitigation of *Sargassum* downstream impacts

1) Improved understanding globally of the tools available for predicting and forecasting HABs
2) A unified community of practice and global coordination surrounding remote sensing, autonomous observing, and modeling approaches relevant to HAB detection, prediction, and forecasting
3) Improved capacity in developing countries surrounding the use and application of remote sensing and modeling tools for HAB monitoring and early warning to coastal communities
4) Global advances in the ability to develop early warning systems for all HAB taxa.

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Goal 6: Marine HAB control and its interaction with environment – biofeedbacks from mitigation interventions

TASKS & OUTCOMES

- Conduct review papers focused on unintended consequences, trade offs, and advice on appropriate use for the different types of tools.
- Promote the uptake of prevention practices
- Identify and evaluate mitigation strategies for their efficacy and safety; includes Identifying regulatory barriers to implementing control efforts.
- *In situ* testing of HAB control measures used by the private industry 5) Collaboration between scientists and engineers working on HAB control methodologies
- Scale up lab-tested technologies to nature
- Phased approaches for the research and implementation of new HAB control strategies

1) Increased commitment from government agencies in certain countries to allocate more funding and resources for HAB control research, although these efforts remain limited in scope relative to the global scale of the HAB issue.
2) Improved understanding of impacts and efficacy in marine environments
3) Advancements in mitigation of real-time HAB events in both freshwater and marine environments.