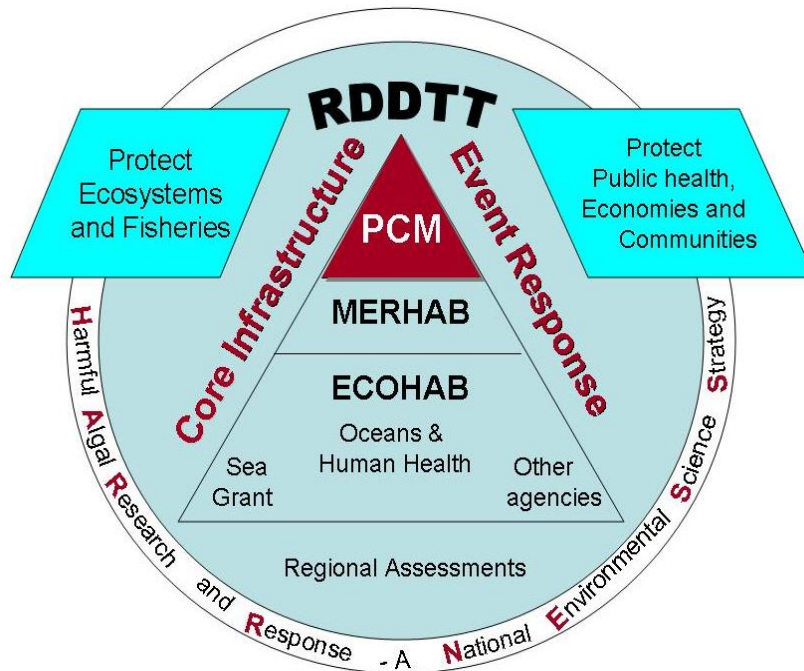


**DRAFT**

**Harmful Algal Bloom  
Research, Development, Demonstration and  
Technology Transfer  
Workshop Report**



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**Workshop held June 22-24, 2007 Woods Hole, MA**

## EXECUTIVE SUMMARY

### Background

The marine and freshwaters of many countries are increasingly impacted by the growing environmental and socioeconomic problem of harmful algal blooms (HABs). HABs are proliferations of marine and freshwater algae that can produce toxins or accumulate in sufficient numbers to alter ecosystems in detrimental ways. These blooms are often referred to as “red tides”, but it is now recognized that such blooms may also be green, yellow, brown, or even without visible color, depending on the type of organisms present. HABs is a more appropriate descriptor.

In U.S. waters HABs are found in expanding numbers of locations and are also increasing in duration and severity. Further, new HAB species or impacts have emerged to pose additional threats to human and ecosystem health in particular regions. The expansion in HABs has led to increased awareness of impacts such as poisonous seafood, toxin-contaminated drinking water, and mortality of fish and other animals (including protected and endangered species), public health and economic impacts in coastal and lakeside communities, losses to aquaculture enterprises, and long-term aquatic ecosystem changes.

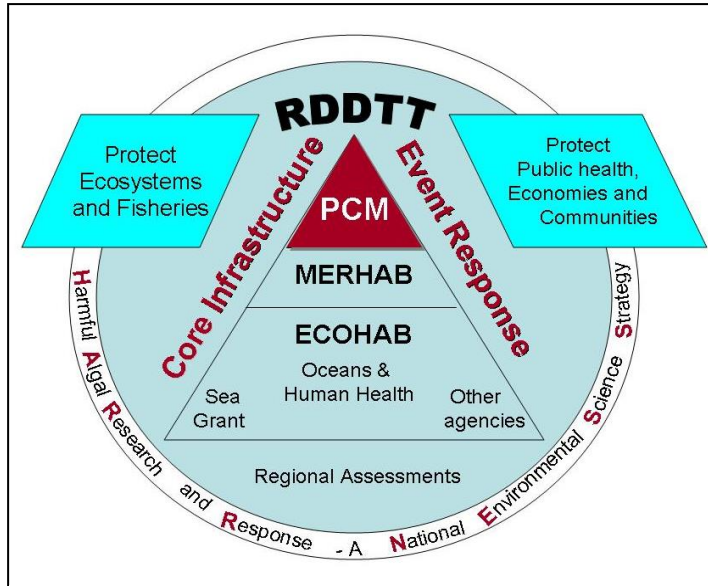
The 1998 *Harmful Algal Bloom and Hypoxia Research and Control Act (HABHRCA 1998)* established research programs to address the U.S. HAB problem. When HABHRCA was reauthorized and expanded to include freshwater in 2004 (*HABHRCA 2004*), it required four interagency reports and plans to assess U.S. HAB problems and update priorities for federal research and response programs. The first, the *National Assessment of Efforts to Predict and Respond to Harmful Algal Blooms in U.S. Water (Prediction and Response Report 2007)*, assesses the extent of the HAB problem in the U.S., details federal, state, and tribal prediction and response programs, emphasizing federal efforts, and highlights opportunities to improve HAB prediction and response efforts and associated infrastructure. A strategy to address these needs for both marine and fresh waters will be included in the follow up *HABHRCA 2004* report, the *National Scientific Research, Development, Demonstration, and Technology Transfer Plan (RDDTT Plan) on Reducing Impacts from Harmful Algal Blooms*, which will be derived in part from this Workshop Report. Besides addressing the needs identified in the *Prediction and Response Report*, the *RDDTT Plan* will also address issues raised in three recent reports developed by the HAB management and research community, *Harmful Algal Research and Response, A National Environmental Science Strategy* (HARRNESS, 2005), *Harmful Algal Research and Response: A Human Dimensions Strategy* (HARR-HD 2006), and the *Proceedings of the Interagency, International Symposium on Cyanobacterial Harmful Algal Blooms: State of the Science and Research Needs (ISOCHAB 2007)*.

### Process for Developing the RDDTT Program

Input for the *RDDTT Plan* was solicited from both the marine and freshwater HAB research and management communities during a workshop in Woods Hole, MA June 22-25, 2007. This

*RDDTT Workshop Report* summarizes the current status of the field, recommends a program to improve HAB prediction and response (Box 1), and suggests an implementation process. The

*RDDTT Plan*, which will be written by the Joint Committee on Ocean Science and Technology Interagency Working Group on Harmful Algal Blooms, Hypoxia, and Human Health and submitted to Congress, will draw from these recommendations.



**Box 1.** Diagram showing the relationship of the three elements of the RDDTT Program with other HAB research and response programs.

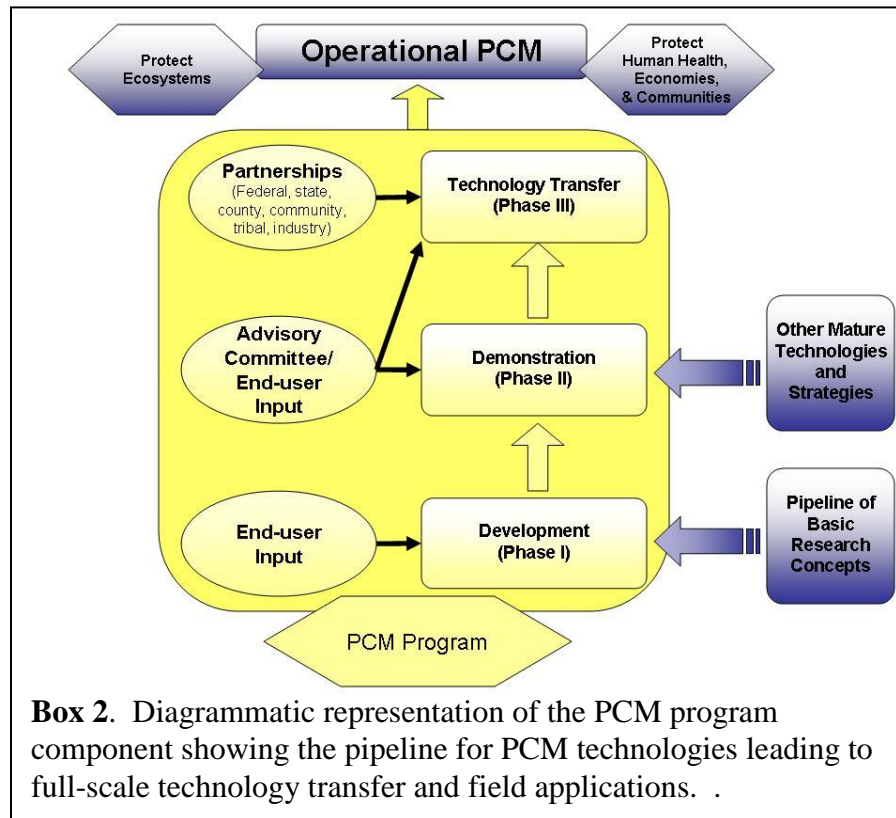
The workshop attendees proposed approaches for an RDDTT Program with three essential components, based on the opportunities for advancement identified in the reports cited above. These are 1) an extramural funding program focused on development, demonstration, and technology transfer of methods for prevention, control, and mitigation (**PCM**) of HABS; 2) a comprehensive national HAB **Event Response** program; and 3) a **Core Infrastructure** program to support

HAB research and response. All three components require social science research related to “human dimensions” and call for the meaningful engagement of at risk and affected communities. These components are interdependent and critical for improving future HAB response (Box 1).

## Prevention, Control, and Mitigation (PCM) Development, Demonstration, and Technology Transfer

The PCM component or sub-program of the RDDTT Program focuses on moving promising technologies and strategies, arising from HAB research from development through demonstration to technology transfer and field application by end users. Programs that would feed technologies to the PCM component would include programs such as the Ecology of Harmful Algal Blooms (ECOHAB), Monitoring and Event Response (MERHAB), Sea Grant, and Oceans and Human Health (OHH). As shown in Box 2, the program work would flow in three distinct stages: 1) The Development phase (Phase 1) advances and evaluates unproven but promising PCM technologies and strategies. 2) The Demonstration phase (Phase 2) tests, validates and evaluates technologies in the field across a broad temporal and spatial scale. 3) The Technology Transfer phase (Phase 3) facilitates the transition of proven technologies and strategies to end users. End users, including local, state, and federal resource and public health managers, non-profit organizations, and a variety of businesses must be involved in all three phases. Projects can enter the extramural PCM program at any phase and would be selected

through peer review competition. Socially responsible development and effective implementation are ensured by the inclusion of social science research in all phases.



Many promising options are already available to feed into the PCM sub-program. Example focal areas within the prevention category include modifications of hydrodynamic conditions in areas subject to HABs, or methods to avoid introducing HABs cells and cysts as invasive species. Although nutrient reduction is also a very promising strategy for HAB prevention, many nutrient management programs already exist and are motivated by issues other than HABs. Methods of control or

bloom suppression through the removal of HAB cells or toxins by biological, chemical, or mechanical means are ready for further investigation. For example, mechanical removal of cells and toxins by clay flocculation is one approach that has already been tested in pilot field studies, so it is ready for further Phase 2 evaluation. A number of biological control methods are ready for Phase 1 development studies in the field, with concomitant research needed in risk communication to foster public understanding and participation in decision making about potentially controversial strategies. Many opportunities exist to improve mitigation activities that reduce the impacts of HABs. A few examples include new methods of monitoring and forecasting HAB cells and toxins, maintaining safe seafood, water, and beaches, preventing and treating human and animal disease syndromes, assessing the socioeconomic impacts of HABs and the effectiveness of PCM strategies, and advancing education and outreach.

All PCM projects will be extramural, competitive, peer-reviewed and funded through an annual request for proposals that will ensure priorities for research and implementation are based both on societal needs and scientific promise of effectiveness. End user input to proposals in all phases and external advisory committee guidance for Phase 2 and 3 projects will facilitate technical success and maximize socioeconomic benefits and opportunities. Involvement of researchers and user groups throughout the PCM development, demonstration, and implementation processes will ensure that projects with the most societal relevance are supported and brought into operational use.

## Event Response

In order to mitigate the impacts of HABs, there is an urgent need to further develop the capacity for anticipating events and responding rapidly. The range of stakeholders involved in event response depends upon the nature of the HAB, the geographic area affected and the implications for human, fish, and wildlife health. States, counties, tribes, and academic researchers are generally the first responders. The aquaculture industry in some instances has also acted as front-line responders. When HAB events occur on small, localized scales, the capacity and financial resources of individual states usually are sufficient to respond quickly and effectively. A good example is the Maine shellfish monitoring and closure program. Under normal conditions, the state is able to mitigate adverse public health outcomes through the imposition of carefully timed and positioned shellfish closures. Many other states also have successful programs in place to manage shellfish closures.

As HABs are occurring at larger scales, greater frequency and scope of impact than in the past, or involve species that are new to state or regional waters, the capacity for responding rapidly is sometimes inadequate or nonexistent. In addition, freshwater HAB events are occurring in states that have never before needed a capacity for response. Toxic freshwater blooms can threaten public water supplies and lead to widespread recreational impacts.

The insufficient capacity for adequate responses to new or large-scale HAB events is in part a product of inexperience, lack of resources, and the unpredictable nature of such events. It is costly and time-consuming to develop a response capacity for events that are sporadic or rare, or for those that have increased in frequency and scale, and for which damages are uncertain. These characteristics argue strongly for a national and regional approaches to event response. In effect, such a program helps a region or the nation insure itself against the public health effects, ecological impacts, and economic damages that could arise from unusual, unpredictable, and devastating HAB events.

It is clear that HAB event response capacities need to be expanded at a national level. Existing program will not be able to address anticipated increases in HAB frequency and intensity.

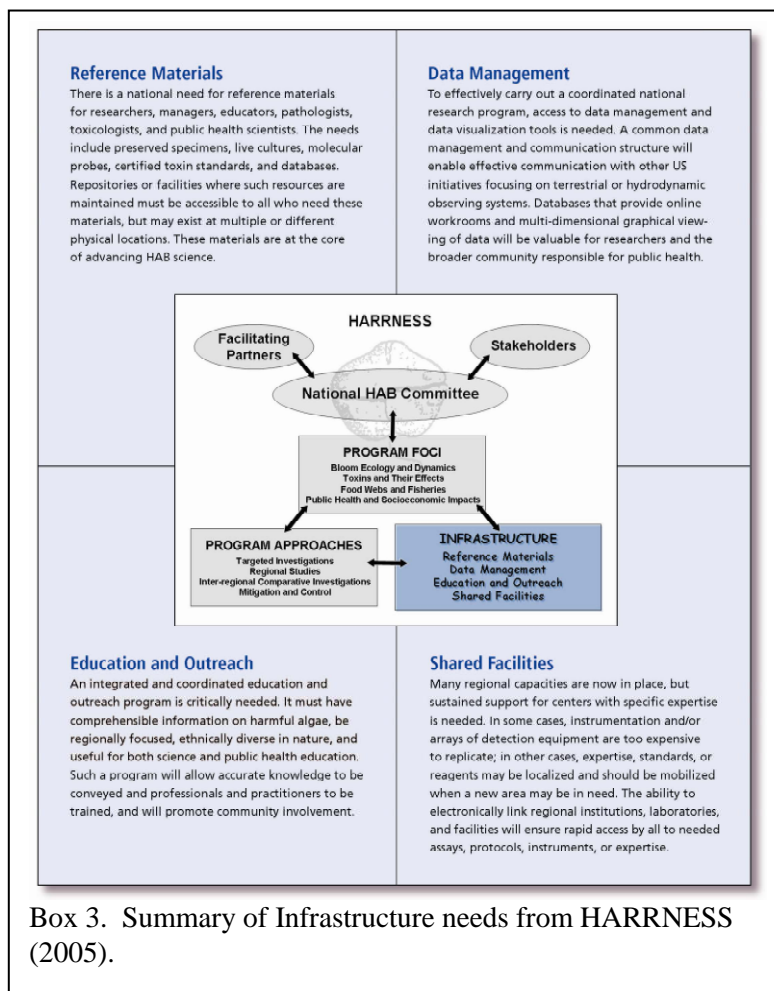
The proposed Event Response component of the RDDTT Program improves access to existing resources through better information sharing, communication, and coordination and provides essential new resources. A regionally based, federal HAB Event Response Program is proposed with National Marine and Freshwater Coordinators, possibly residing in NOAA and EPA, potentially linked to a network of Regional Coordinators. Coordinators would maintain web sites cataloging regionally available resources, assist in developing regional response plans, organize training and information-sharing workshops, and provide coordination during events, if requested by regional, state, or local authorities. The Regional Coordinators would also request resources from other regions and, if needed, request funding from a national Event Response Contingency Fund, modeled after the current, but inadequately funded NOAA Event Response Program ([http://www.cop.noaa.gov/stressors/extremeevents/hab/current/fact-ev\\_resp.html](http://www.cop.noaa.gov/stressors/extremeevents/hab/current/fact-ev_resp.html)). A

national Technical Assistance Fund would provide extramural funds for activities designed to improve response to future events; activities would be selected by competitive peer review.

## CORE Infrastructure

The past decade has resulted in tremendous advances in the community's understanding of HAB dynamics, from physiology and toxin expression to bloom transport and economic impact. The general increase in knowledge has been matched by rapid expansion in the capability for toxin and species detection using laboratory, hand-held, and in- and above-water technologies. Advancements in both basic knowledge and in methods and tools have led to significant new opportunities for furthering understanding and for protecting human health. However, as the field has matured, the infrastructure needs of the community have also increased. These core needs form the foundations upon which the science and its management applications depend. Many of the associated costs are far greater than can be borne by individual investigators or end users. These needs cross-cut science and management and bridge individual agency interests. While in some cases they may intersect with the goals of other US programs already in place, existing programs are inadequate to meet these requirements. The needs for critical infrastructure were identified in the first National HAB plan in 1993 and strongly reiterated in the revised national

plan for 2005-2015 (HARRNESS 2005). Critical infrastructural needs can now be identified and efforts made to obtain the financial and administrative support needed to make them a reality, with an ultimate goal of growing a greater community through collaboration.



Box 3. Summary of Infrastructure needs from HARRNESS (2005).

Researching and implementing new PCM strategies and improving event response will not be possible without enhancing CORE infrastructure, including 1) increasing availability of adequate analytical facilities, reference and research materials, toxin standards, culture collections, tissue banks, technical training, and access to data; 2) improving integration of HAB activities with existing monitoring and emerging observational programs; and 3) enhancing communication and regional and national coordination. Two

complementary approaches are proposed to accomplish these goals: 1) Establish an interagency, competitive, peer reviewed extramural funding program that will support CORE infrastructure needs and 2) Develop a regional network with national and regional coordinators to leverage existing resources, encourage coordination and foster active communications with users and stake holders within and between regions.

## **RDDTT Program Implementation**

The proposed RDDTT Program (Box 1) is comprised of three components: 1) a component for HAB prevention, control, and mitigation (PCM), 2) an Event Response component, and 3) a Core Infrastructure component. The need and community readiness for each varies with the status of currently existing research and the planning required for each activity. The RDDTT program can, therefore, be implemented in stages corresponding to the reauthorizations of HABHRCA every five years, with projected funding needs increasing as the components mature (Box 4). The PCM component forms the core of the RDDTT Program because it is only through PCM that the grave risks posed by HAB expansion can be successfully confronted in the long term. Thus, in the first stage (FY 09- FY 13), the greatest emphasis is on developing the PCM component because many promising technologies, developed through other HAB research programs, are ready to be transitioned to operational use. Since CORE infrastructure and Event Response are integral to developing HAB response, these programs should be initiated in the first five years, but not fully implemented until the next five year reauthorization (FY 14-FY 18).

Implementation requires both changes in authorizing legislation and increases in appropriations. Although the RDDTT will be the program that the public will most readily perceive as ‘progress’ in the management of HABs, the program is part of an integrated approach to HAB risk management that includes other research and response programs. Thus, it is essential that the RDDTT program be established as a separate element within the national HAB program (HARRNESS 2005), with the expectation that related HAB research and response programs will provide the innovative new technologies and approaches as well as the ecological and oceanographic context to guide its practical and applied activities. When HABHRCA is reauthorized, the RDDTT program should therefore be highlighted along with the existing ECOHAB and MERHAB programs, with the three components of the RDDTT Program specifically listed.

Since many agencies are involved in HAB research and response, it will be necessary to specify that the RDDTT Program is an interagency program and to provide funding to agencies with major roles. In particular the HABHRCA reauthorization should identify and authorize freshwater programs that would fall under the purview of relevant agencies, such as EPA, in addition to the marine and coastal programs authorized in NOAA. Separate funding lines are needed since NOAA has a geographic mandate that includes marine coastal waters and the upper reaches of estuaries, and the Great Lakes. Many freshwater HAB problems fall outside these boundaries, however, and therefore will need to be supported through separate appropriations to the EPA. Other agencies, such as FDA, CDC, NSF, NIEHS, and USGS, also contribute substantially and should be named as partners in the national HAB program.

Funding to implement the freshwater and marine components of the RDDTT program over the next five years (FY09-FY13) is roughly projected to be equivalent to that of the ECOHAB and MERHAB programs. Full implementation will thus require additional funding of \$6.5M (FY 08) to \$10.5M (FY 13).

#### **Box 4. Outline of HAB RDDTT Program Components**

1. Prevention, Control, and Mitigation Development, Demonstration, and Technology Transfer
  - a. Move promising technologies and strategies from other HAB research programs to end users
  - b. Three phases: development (Phase 1), demonstration (Phase 2), technology transfer to end users (Phase 3).
  - c. Competitive, peer-reviewed extramural funding\*
2. Event Response
  - a. Provide immediate assistance during events and improve response capacity\*\*\*
  - b. National and regional coordinators and regional network of resources\*\*
  - c. Contingency Fund—expanded from and modeled after current Event Response ([http://www.cop.noaa.gov/stressors/extremeevents/hab/current/fact-ev\\_resp.html](http://www.cop.noaa.gov/stressors/extremeevents/hab/current/fact-ev_resp.html))
  - d. Technical Assistance Fund—competitive peer-reviewed extramural program\* to enhance response capacity
3. Core Infrastructure
  - a. Increase availability of analytical facilities and reference and research materials, improving integration of HAB activities with existing monitoring and emerging observational programs, enhance communication and coordination
  - b. National and regional coordinators and regional network of resources\*\*
  - c. Competitive peer-reviewed extramural funding program\* to develop and support infrastructure

\*Structure of competitive peer-review may vary to suit the purpose of the program

\*\*Coordinators for event response and infrastructure can be the same people. In phased implementation, the National Coordinators would be put in place first and regional coordinators would be added in next phase.

\*\*\*Requests for assistance would most likely come from state, local or tribal governments.

## **Benefits of RDDTT Implementation**

Full implementation of all the components of an RDDTT Program will yield many benefits for the public health and management communities and for residents, resource users, businesses and other stakeholders in at-risk and affected communities. It will also address many of the frustrations people living in HAB impacted communities experience and provide them with new strategies to address the problems. These benefits include:

- Healthier fisheries industries selling seafood that is safer with respect to biotoxins;
- Reductions in the frequency and impacts of highly toxic or large, unsightly and noxious accumulations of algae;
- Ecosystems that are less threatened by invasions of non-indigenous HAB species;
- Mitigation of bloom impacts using a suite of practical, previous tested strategies;
- Sophisticated yet less expensive, easy to operate instruments for HAB detection;
- Teams of scientists, managers, and community leaders prepared to respond to events;
- Improved prediction and early warning of blooms and HAB impacts due to better predictive models, networks of moored automated observing systems, and satellite surveillance capability for detection and tracking over large distances;
- Improved human health and ecosystem risk assessment;



- Effective means of educating and warning the public.

The fully-implemented RDDTT Program will link science and management to achieve vastly improved mitigation, control, and prevention, and education. Full implementation will not be simple and will require substantial investment. The socioeconomic costs of not addressing these needs, however, greatly exceed the projected investment.