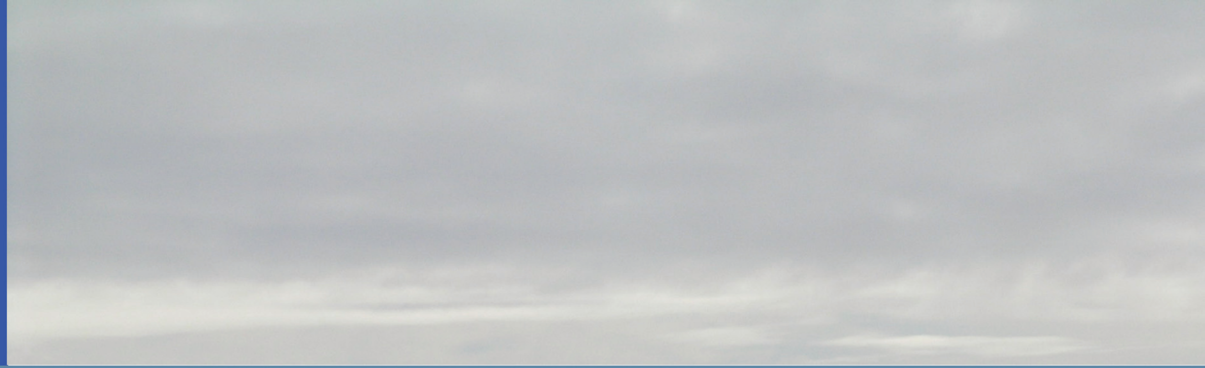

Harmful Algal Research and Response: A Human Dimensions Strategy

Following the Recommendations of the National Plan for Algal Toxins and Harmful Algal Blooms

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To obtain a copy electronically, please visit the following websites:

NOAA National Centers for Coastal Ocean Science
http://coastalscience.noaa.gov/stressors/extremeevents/hab/HDstrategy.pdf

National Office for Marine Biotoxins and Harmful Algal Blooms
Woods Hole Oceanographic Institution
http://www.whoi.edu/redtide/nationplan/nationplan.html

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Foreword

The Harmful Algal Bloom (HAB) community welcomes *Harmful Algal Research and Response: A Human Dimensions Strategy* (HARR-HD) as the first report to expand upon the recommendations of *Harmful Algal Research and Response: A National Environmental Science Strategy* 2005–2015 (HARRNESS). HARRNESS is a new national plan for HABs that builds on the US Commission on Ocean Policy's Final Report to the President and Congress, *An Ocean Blueprint for the 21st Century*. Specifically, it elaborates upon the *Blueprint's* themes related to HABs and specifies actions needed to implement a new framework to coordinate activities, target funding, and achieve a vision for managing HABs in the coming decade. HARRNESS updates the *National Plan for Marine Biotoxins and Harmful Algal Blooms* (1993), which served the HAB community for more than a decade, and expands this mandate by including freshwater HABs as recommended by the 2004 reauthorization of the Harmful Algal Bloom and Hypoxia Research and Control Act (HABHRCA). The HARR-HD initiative is consistent with the inclusion of *Public Health and Socioeconomic Impacts* as a HARRNESS research focus along with *Bloom Ecology and Dynamics*, *Toxins and Their Effects*, and *Food Webs and Fisheries*. Also of relevance to HARR-HD are four HARRNESS infrastructure initiatives: reference materials, data management, education and outreach, and shared facilities.

HARR-HD develops six areas of human dimensions research integral to assessing and mitigating the impacts of algal toxins and harmful algal blooms. The first three (*Socioeconomic Impacts*, *Public Health Impacts*, and *Recreational and Drinking Water Impacts*) provide a social scientific elaboration of and guidance for implementing these research needs as described in the *Public Health and Socioeconomics Impacts* focal area of HARRNESS. Another area of HARR-HD research, *Education and Outreach*, extends the infrastructure initiative of the same name in HARRNESS. The other two HD research areas expand HARRNESS in important new directions. *Risk Communication* fills a critical gap in national HAB capacity that is well-recognized, but not well-developed in HARRNESS. *Coordinating Approaches to HAB Problems* provides a fresh approach to understand and optimize the interactions among various agencies and stakeholders in the HAB community that play an integral role in promoting all aspects of HARRNESS and will pave the way to reach the plan's vision for 2015.

HARR-HD opens Harmful Algal Research and Response to even broader communities of scientists, resource managers, affected communities, and concerned citizens. This action is welcomed by the HAB community. Indeed, the intent of HARRNESS was to expand community involvement. The planning and formulation process for HARRNESS resulted in the new plan being vetted by the broadest possible cross section of the US HAB community, including program managers, regulatory officials, scientists, and industry representatives. We hope that, as HARR-HD is vetted by the larger social science community through their engagement and collaboration with scientists in the HAB community, a full integration of the human dimension of HABs will be achieved in each of the HARRNESS research themes and infrastructures.

HARR-HD arrives as the HAB community is beginning to implement HARRNESS. The first step in the process was the formation of a rotating, interdisciplinary group of individuals representing priority research areas referred to as the National HAB Committee (NHC). The mission of the NHC is to facilitate coordination and communication of activities for the US HAB community at a national level. This committee commenced its tenure in June of 2006. Concurrent with the formation of the NHC is a requirement by HABHRCA for an Interagency Task Force to consult with the HAB community to develop scientific assessments of harmful algal blooms and freshwater blooms, a report on prediction and response, and a plan to reduce impacts. The advent of HARR-HD brings social science research into the HAB community at a most opportune time.

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Executive Summary

Harmful Algal Research and Response: A Human Dimensions Strategy (HARR-HD) justifies and guides a coordinated national commitment to human dimensions research critical to prevent and respond to impacts of harmful algal blooms (HABs). Beyond HABs, it serves as a framework for developing human dimensions research as a cross-cutting priority of ecosystem science supporting coastal and ocean management, including hazard research and mitigation planning. Measuring and promoting community resilience to hazards require human dimensions research outcomes such as effective risk communication strategies; assessment of community vulnerability; identification of susceptible populations; comprehensive assessment of environmental, sociocultural, and economic impacts; development of effective decision support tools; and improved coordination among agencies and stakeholders. HARR-HD charts a course for human dimensions research to achieve these and other priorities through coordinated implementation by the Joint Subcommittee on Ocean Science and Technology (JSOST) Interagency Working Group on HABs, Hypoxia and Human Health (IWG-4H); national HAB funding programs; national research and response programs; and state research and monitoring programs.

Harmful Algal Blooms (HABs). Harmful algal blooms (HABs) are "proliferations of microscopic algae that harm the environment [and humans] by producing toxins that accumulate in shellfish or fish, or through the accumulation of biomass that in turn affects co-occurring organisms and alters food webs in negative ways. Like much of the world's coastlines, nearshore marine waters of the US have experienced increases in the number, frequency, and type of HABs in recent years. Freshwaters are also experiencing HAB events" (HARRNESS 2005) (Fig. 1).

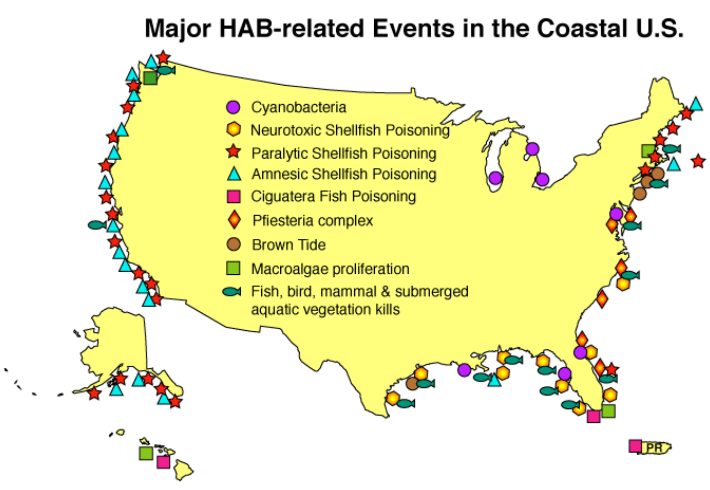


Figure 1. *Major HAB Events in the US. (NCCOS and WHOI, www.whoi.edu/redtide/HABdistribution/HABmap.html)*

Human Impacts of HABs. In their Final Report to the President and Congress, *An Ocean Blueprint for the 21st Century*, the US Commission on Ocean Policy recognizes that HABs are a significant threat to coastal environments and communities (USCOP 2004). The human impacts of HAB events are profound, including illness and mortality resulting from direct consumption of or indirect exposure to contaminated shellfish or fish; lost revenue for coastal economies dependent on seafood harvest or tourism; disruption of subsistence activities; loss of community identity tied to coastal resource use; and disruption of social relationships and cultural practices of families and communities.

National HAB Plan and Legislation. The recent National Plan for Algal Toxins and Harmful Algal Blooms, *Harmful Algal Research and Response: A National Environmental Science Strategy* (HARRNESS), calls for a coordinated, interdisciplinary national research and response program to reduce impacts from harmful algal blooms (HABs) (Fig. 2). By establishing recommendations for public health and socioeconomic research coupled with a comprehensive biophysical research and monitoring strategy, HARRNESS provides information critical to implement the 2004 reauthorization of the Harmful Algal Bloom and Hypoxia Amendments Act (HABHRCA) (PL 108-456). JSOST

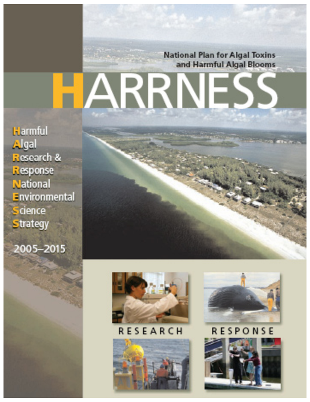


Figure 2. *National HAB Plan (HARRNESS)*

established the IWG-4H to implement the Oceans and Human Health Act of 2004 and HABHRCA, which requires the President to submit a number of reports to Congress including scientific assessments of coastal and freshwater HABs and hypoxia, a report on HAB prediction and response, and a plan to reduce HAB impacts (see Recommendation 1).

Development of a Human Dimensions Research Strategy. Recent development of the National HAB Plan, coupled with legislation requiring considerable interagency focus on HABs, provides an opportunity to expand areas of HAB research that will better focus national commitments to protect environmental systems, public health, economies, and communities. Recognizing the need for guidance to implement the recommendations of the National Plan for public health and socioeconomic research, the National Centers for Coastal Ocean Science (NCCOS) of the National Oceanic and Atmospheric Administration (NOAA) convened a multi-agency workshop on the Human Dimensions of HAB Response in September of 2005. The workshop brought together federal, state, and non-governmental partners in the HAB research and response community with a cross-section of specialists in human dimensions areas critical to improve mitigation strategies (including anthropologists, economists, epidemiologists, risk communication specialists, and educators) (see Appendix 2 for a list of workshop participants). A subset of workshop participants developed the following report, *Harmful Algal Research and Response: A Human Dimensions Strategy* (HARR-HD) (see list of contributors above) (Fig. 3).

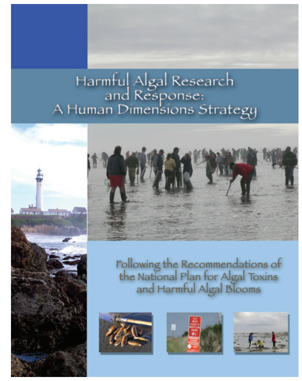


Figure 3. *Human Dimensions Research Strategy (HARR-HD)*

Research Strategy Outline

1. Socioeconomic Impacts
   - 1.1 Identifying Data Needs
   - 1.2 Assessing Social Impacts
   - 1.3 Assessing Economic Impacts
   - 1.4 Assessing Community Vulnerability
   - 1.5 Assessing Economic Benefits of Forecasts
2. Public Health Impacts
   - 2.1 Developing Diagnostic Tools
   - 2.2 Improving Surveillance
   - 2.3 Developing Epidemiological Methods
   - 2.4 Identifying Susceptible Populations
3. Recreational and Drinking Water Impacts
   - 3.1 Improving Monitoring and Documentation
   - 3.2 Developing Short-Term Response Plans
   - 3.3 Developing Water Quality Standards
4. Risk Communication
5. Coordinating Approaches to HAB Problems
6. Education and Outreach

Research Topic Sections

1. HARRNESS Recommendation
2. Research Objectives
3. Example Project(s)
   - Title
   - Description
   - Methods
   - Outcomes
   - Challenges
   - Expertise Needed
   - Timeline

Figure 4. *Organization of the HARR-HD Research Strategy*

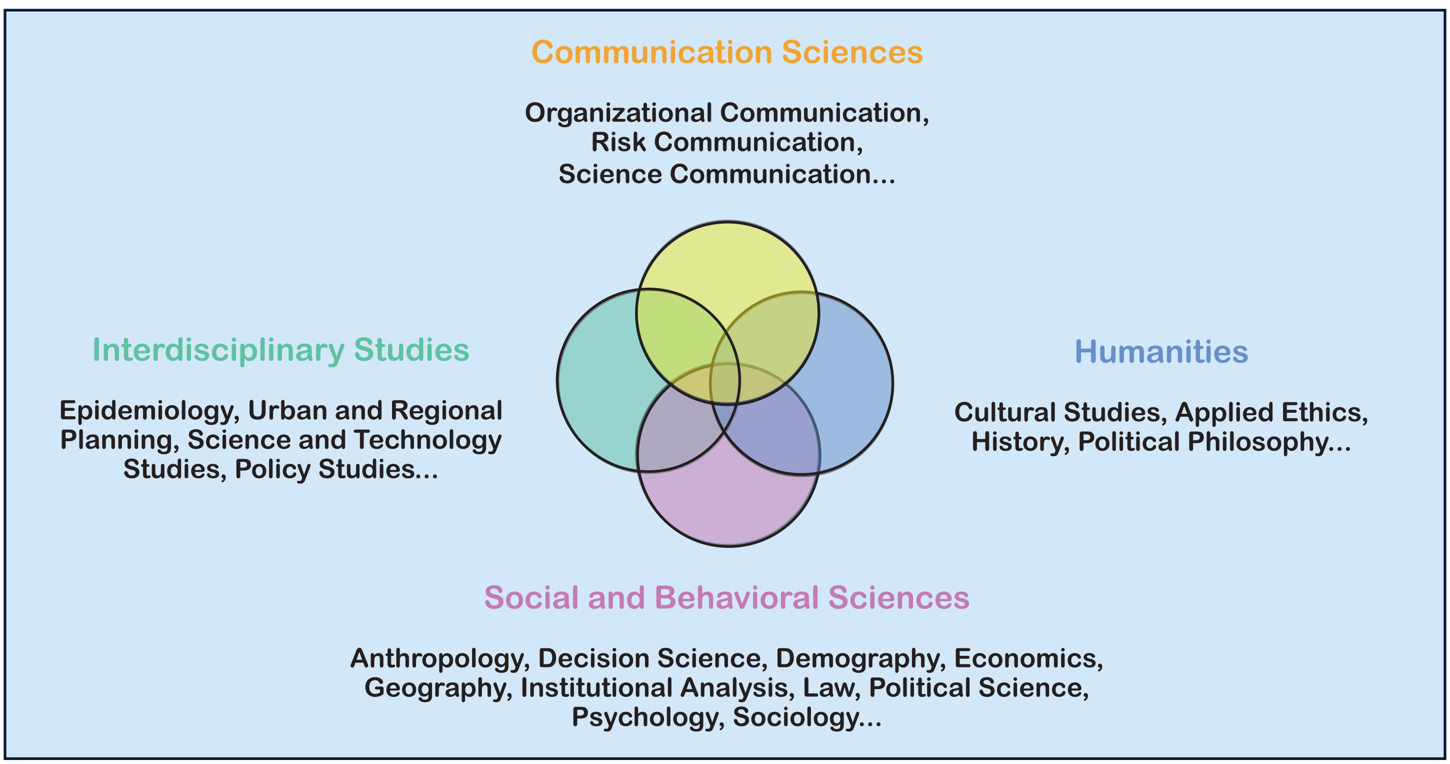
Human Dimensions Research Strategy. HARR-HD provides a research strategy that expands on the *Public Health and Socioeconomic Impacts* section of HARRNESS. The research strategy puts forth six areas of human dimensions research critically needed to reduce environmental and human impacts of HABs: socioeconomic impacts, public health impacts, recreational and drinking water impacts, risk communication, coordinated approaches to HAB problems, and education and outreach. Within these broad areas, individually authored sections are devoted to more specific research topics essential to achieve recommendations put forth in HARRNESS. Each section states the HARRNESS recommendation it expands, provides an overview of the research topic, outlines research objectives addressing the topic, and suggests an example project to achieve the objectives (Fig. 4). Research objectives and example projects are intended to provide a framework for programmatic development and requests for research proposals (RFPs).

Since HARR-HD has not been widely reviewed by an external social science community, it should be viewed as an important first effort to stimulate and guide routine integration of public health, sociocultural, and economic researchers and research programs into national efforts to implement HARRNESS and HABHRCA – especially the non-economic social sciences such as risk communication, anthropology, and sociology, which are under-utilized relative to their essential role.[1] Diverse human dimensions disciplines are integral to reducing impacts from HABs and, more generally, supporting coastal and ocean resource management (Fig. 5).

Benefits of Public Health and Socioeconomic Research for HAB Response

Substantial investment in public health and socioeconomic research is needed to enable resource management and public health agencies, affected sectors and communities, and biophysical scientists to develop and implement coordinated, effective responses to HAB events on regional and local scales. This report de-

***Figure 5**. Diverse Human Dimensions Disciplines Integral to Coastal and Ocean Resource Management*



[1]For example, based on data provided by NOAA's National Center for Sponsored Coastal Ocean Research (CSCOR), from 1999-2004, the Ecology and Oceanography of Harmful Algal Blooms (ECOHAB) interagency HAB research funding program allocated zero funds to the non-economic social sciences, e.g., anthropology, sociology, risk communication, and institutional analysis (not including epidemiology). To provide a point of reference, ECOHAB was committed to spending roughly $65M from 1997-2007.

scribes human dimensions research critical to achieve the following benefits anticipated by implementation of HARRNESS and HABHRCA.

Improved Protection of Human Health

- Understanding how audiences perceive and respond to HAB information will enable communication strategies that prevent exposure and disease.
- Collecting epidemiological information describing the extent of exposure and prevalence of HAB-related illnesses will inform public health decisions in anticipation of and response to HAB events.
- Developing strategies for case reporting, including approaches that do not require patient interaction with the medical community, will improve accuracy of disease incidence assessments and focus exposure prevention strategies.
- Identifying susceptible populations will further focus exposure prevention strategies.
- Identifying effective regulatory, institutional, and participatory strategies will facilitate short-term response to algae-contaminated water and incorporation of algal toxin standards into water quality standards.
- Assessing public perceptions of algal toxins in affected drinking and recreational waters, and the extent of public support for increased monitoring, will inform water quality monitoring and short-term response strategies.

Improved Prevention of and Response to Sociocultural and Economic Impacts

- Identifying demographic groups most vulnerable to sociocultural and economic impacts of HAB events will focus prevention and mitigation efforts.
- Conducting a baseline assessment of agencies and partners integral to current prevention and mitigation efforts, and identifying effective strategies for coordination, will inform development of effective partnerships on local and regional scales.
- Understanding how communication of HAB forecasts, threats, and other information mediates public perceptions and behaviors will suggest communication strategies effective for prevention and mitigation of human impacts.

Assessments of Sociocultural, Economic, and Public Health Impacts

- Establishing formal, standardized data collection will enable accurate assessments of the sociocultural, economic, and public health impacts of HAB events on local and regional scales. Impact assessments will justify investment in HABs and, as recognized by the National Environmental Policy Act (NEPA), are critical to select effective prevention and response strategies.

Improved Coordination for Research and Response

- Analyzing the coordination of agencies and stakeholders on regional and local levels will provide lessons learned, models of effective partnership for research and response, and strategies for avoiding unnecessary duplication of activities and funds.

An Educated and Informed Public

- Engaging communities to foster awareness of HABs and trust in resource management agencies will stimulate stewardship of coastal ecosystems and responses to HAB events that minimize sociocultural, economic, and public health impacts.

Assessments of the Benefits of HAB Forecasts

- Assessing the effectiveness of HAB forecasts for reducing sociocultural, economic, and public health impacts will enable public agencies to demonstrate the value of their research investments.
- Assessing the economic value of HAB forecasts will enable agencies and community groups to evaluate and measure the benefits of mitigation and outreach.

Decision Support for Policy Makers, Coastal Managers, and Others

- Economic analysis identifying value trade offs fundamental to policy and management decisions will support identification and selection of policy frameworks and management approaches for preventing and mitigating environmental and human impacts of HABs.
- Economic and sociocultural assessments documenting human use patterns in and interactions with HAB-affected environments will enable coastal managers to design strategies to prevent or mitigate HAB impacts on individuals and communities.

Improved Development and Transfer of Technologies

- Assessing the needs of coastal managers, educators, public health personnel, and other decision makers will guide the development and delivery of tools to effectively assess, prevent and respond to environmental and human impacts of HABs, e.g. clinical tools for diagnosing HAB illnesses.

Cross Cutting Value of HARR-HD

The value of HARR-HD extends beyond HABs to provide a framework for human dimensions research critical to measure and promote the resilience of coastal communities to multiple hazards, including cumulative and episodic human impacts (such as pollution and oil spills) in addition to chronic and episodic natural events (such as droughts and hurricanes). Accordingly, HARR-HD provides a model for developing human dimensions research as a cross-cutting priority of coastal hazard research and mitigation planning, a goal of the Joint Subcommittee on Ocean Science and Technology (JSOST) established at a recent public workshop informing development of a national Ocean Research Priorities Plan (ORPP) (http://ocean.ceq.gov/about/docs/JSOST_nathaz.pdf).

Sociocultural, Economic, and Public Health Impacts of HABS

The human impacts of HABs are profound, including illness and mortality resulting from direct consumption of or indirect exposure to contaminated shellfish or fish; lost revenue for coastal and linked economies dependent on seafood harvest or tourism; disruption of subsistence activities; loss of community identity tied to coastal resource use; and disruption of social relationships and cultural practices of families and communities. Impacts are both direct (such as shellfish poisoning) and indirect (such as psychological trauma and lost wages resulting from shellfish poisoning). Below, we classify impacts into public health, economic, and sociocultural categories. However, it is important to recognize interactions across these dimensions of human social life. For example, economic hardship experienced by coastal communities can place burden on social service agencies or introduce stress in family relationships.

> **"The cultural significance of joining with friends or family to successfully brave the natural elements to take home a sport limit of fresh razor clams cannot be understated."** - Dan L. Ayres, Coastal Shellfish Lead Biologist, Washington Department of Fish and Wildlife

Sociocultural Impacts

HARRNESS merges the sociocultural and economic impacts of HAB events into a single category of "socioeconomic" impacts. We treat sociocultural impacts as a separate category in order to emphasize that the impacts of HABs include not only economic costs, but also social and cultural costs for individuals, families, tribes, occupational groups, recreational groups, and geographic communities. The term "sociocultural" encompasses the variety of human interactions that enable groups, and their individual members, to survive and construct meaning. These interactions are social, political, organizational, and interpersonal as well as economic. "Sociocultural" also encompasses the knowledge, beliefs, norms, values, and customs that reflect the culture and heritage of a group. For example, as discussed below, techniques for harvesting, cleaning, and canning razor clams are part of the cultural heritage of coastal communities in Washington. The study of social experience is broadly interdisciplinary, weaving together disciplines such as anthropology, communications, demographics, ethics, organizational science, political science, and sociology.

The sociocultural impacts of HABs remain undocumented, although not unobserved. For instance, the razor clam fishery in Washington is not only a significant source of revenue for tourism-dependent businesses such as restaurants and motels, but also an important source of community identity and basis for tribal subsistence. Razor clam harvesting, cleaning, cooking, eating, and canning have been an important focus of family relationships and local culture in Washington coastal communities for many generations. Periodic and sometimes prolonged closures of the recreational fishery have diminished the collective identity of surrounding communities and decreased opportunities for family and community recreation, including razor clam digging. Studies are needed to determine the extent to which HABs and management responses (such as fisheries closures) directly or indirectly result in family disruption, community conflict, disruption to or shifts in livelihoods, threats to subsistence, increased reliance on social services, degradation of cultural practices and values, loss of recreational opportunities, and other sociocultural impacts. While it may not be possible to place a dollar value on all of these impacts, it is important to document them so that appropriate mitigation strategies can be funded, planned, and implemented.

Economic Impacts

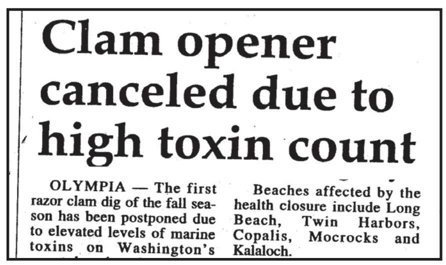
Using time series data from 1987 to 2002, researchers at the Marine Policy Center of the Woods Hole Oceanographic Institution developed an unpublished estimate of the average annual national aggregate economic effects from HABs. The estimate was developed using methods identical to those used to develop earlier estimates of HAB economic effects in the US during 1987-1992 (Hoagland et al. 2002). The estimated figure is approximately $75 million per year, which is at the same order of magnitude as historical examples of extreme, but infrequent, local HAB events that have resulted in major economic impacts. This figure is an aggregate of estimates for the categories of public health costs (divided between shellfish poisoning and ciguatera fish poisoning), commercial fishing losses, recreation and tourism losses, and monitoring and management costs.

Public health effects are the largest component of this estimate, representing about 42 percent of nationwide average effects. Ciguatera fish poisonings average nearly 20 times those arising as a consequence of shellfish poisonings. The next largest component of this estimate is commercial fisheries effects, which represent nearly 40 percent of nationwide average effects. Roughly one third of nationwide commercial fisheries effects may be due to untapped surf clam fisheries in the Bering Sea and on Georges Bank. Recreation and tourism effects account for about 15 percent of nationwide average effects. Economic effects in this category are highly uncertain because recreational users and tourists are likely to switch to alternative activities when faced with a HAB event. Monitoring and management costs represent 4 percent of nationwide average effects. This management estimate does not include federal expenditures for scientific research programs on HABs, which have significantly grown in recent years.

Public Health Impacts

HARRNESS recognizes that "the demand for seafood as part of a healthy diet, combined with globalization of trade and tourism, expands the geographic boundaries for human exposure and subsequent illness … beyond historically affected communities" (HARRNESS 2005, 55). The best-characterized of these illnesses are those associated with exposure to marine microalgae toxins and can be classified by vector – e.g., consumption of contaminated shellfish or reef fish. Paralytic shellfish poisoning, neurotoxic shellfish poisoning, diarrhetic shellfish poisoning, and amnesic shellfish poisoning are caused by eating scallops, mussels, clams, oysters, cockles, and certain crabs contaminated with various toxins. These illnesses may also be caused by eating the contaminated viscera of other marine species such as white croaker and anchovy. Ciguatera fish poisoning is caused by eating large predatory reef fish that have accumulated ciguatoxins. There is no official name for the symptoms caused by exposure to aerosolized red tide toxins, but the symptoms include upper and lower respiratory irritation and asthma exacerbations in sensitive people. A summary of these illnesses is presented in Backer et al. (2003).

Less well-characterized than illnesses caused by marine algae are illnesses caused by exposure to freshwater microalgal toxins. In many areas of the world (e.g., Australia and the US), HABs with the potentially greatest public health impact are cyanobacteria blooms (called "CyanoHABs") in drinking water and in water used for recreation (e.g., rivers and lakes). While there are no named syndromes, cyanobacterial toxins have caused outbreaks of gastrointestinal illness and liver failure in communities where blooms have affected drinking water sources (Backer 2002). In addition, people have reported skin irritation and rashes following occupational or recreational exposure during *Lyngbya* blooms.



Clam opener canceled due to high toxin count

OLYMPIA — The first razor clam dig of the fall season has been postponed due to elevated levels of marine toxins on Washington's

Beaches affected by the health closure include Long Beach, Twin Harbors, Copalis, Mocrocks and Kalaloch.

Washington Razor Clam Dig Cancelleation (Washington Department of Fish and Wildlife).

Human Dimensions Research Strategy

Building on HARRNESS, the research strategy below puts forth six areas of human dimensions research critically needed to mitigate environmental and human impacts of HABs: socioeconomic impacts, public health impacts, recreational and drinking water impacts, risk communication, coordinating approaches to HAB problems, and education and outreach. Within these broad areas, individually authored sections are devoted to more specific research topics essential to achieve recommendations put forth in HARRNESS (Fig. 6). Each section notes the HARRNESS recommendation it expands, provides an overview of the research topic, outlines research objectives addressing the topic, and suggests an example project to achieve the objectives (Fig. 4). The research objectives and example projects are intended to provide a framework for programmatic development and requests for research proposals (RFPs).

Research Strategy Themes

1. Socioeconomic Impacts
2. Public Health Impacts
3. Recreational and Drinking Water Impacts
4. Risk Communication
5. Coordinating Approaches to HAB Problems
6. Education and Outreach

Figure 6. Research Strategy Themes

1. Socioeconomic Impacts

Building on the "Socioeconomic Impacts of HABs" section of HARRNESS (page 55), this section discusses the following research topics and needs (Fig. 7).

Socioeconomic Impacts – Research Topics and Needs

1.1 Identifying Data Needs
Research Need: Characterize the data needed to assess the economic, public health, and sociocultural impacts of HAB events on local and regional scales. Facilitate comprehensive and coordinated data collection and storage across affected sectors and communities.

1.2 Assessing Social Impacts
Research Need: Assess the sociocultural impacts of HAB events at local and regional scales.

1.3 Assessing Economic Impacts
Research Need: Assess the economic impacts of HAB events at local and regional scales.

1.4 Assessing Community Vulnerability
Research Need: Assess the vulnerability of actual and potential HAB-affected communities to sociocultural and economic impacts of HAB events.

1.5 Assessing Economic Benefits of Forecasts
Research Need: Conduct socioeconomic studies of how user groups will benefit from HAB forecasts at different temporal and regional scales.

Figure 7. Socioeconomic Impacts - Research Topics and Needs

1.1. Identifying Data Needs

Research Need: Characterize the data needed to assess the economic, public health, and sociocultural impacts of HAB events on local and regional scales. Facilitate comprehensive and coordinated data collection and storage across sectors and communities.

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Contributor: Lorraine Backer

HARRNESS Recommendation: "Compile data and calculate the socioeconomic impacts of HAB events at local and regional scales" (HARRNESS, 55).

HABs are complex phenomena, both in their biophysical attributes (i.e., their causation and development over space and time) and their impacts on human communities. HARRNESS suggests that approaches to the management of HABs have not sufficiently reflected this complexity. The report concludes that improved data collection on an ongoing basis is critical to improved understanding of HABs and their impacts. Biophysical data, emphasized in HARRNESS, are clearly important because they can be used to test hypotheses regarding triggers of HAB events, circumstances which make them especially severe, and ecosystem impacts. These data also inform the development of management approaches.

From a policy and management standpoint, it is also important to have robust empirical information regarding the potential threats and impacts of HABs on economies, sociocultural dimensions, and public health. Data on the biophysical attributes of HAB events alone are insufficient to predict and assess the impacts of blooms, and to determine the most effective allocation of scarce resources to prevent or mitigate these events and their impacts. In addition to understanding the biophysical context of HABs, it is critical to understand their economic, sociocultural, and public health context.

Responses to HAB events typically consist of some subset or combination of various management options, e.g., closures and their enforcement, education and public outreach, *in situ* mitigation, processing to remove toxins in the field, or advance harvesting of a potentially affected resource for placement in protected areas. The optimal portfolio of management measures in anticipation of or response to a bloom will surely depend on its biophysical nature, but also on the impact of the bloom on communities dependent upon affected resources, e.g., fisheries, beaches, and coastal waters. In the case of commercial fisheries, for example, economic and sociocultural considerations important to effective response include lost revenue and social disruption resulting when fishery participants seek temporary or permanent employment in other sectors, the cultural importance of an affected resource or its harvest, and the level of compliance with closures, which mediates public health risk.

HARRNESS builds on a call by the US Commission on Ocean Policy for shared infrastructure and other measures to reduce the impacts of HABs. As stated in the Ocean Commission's report to Congress, *Ocean Blueprint for the 21st Century*, "as more data are collected on HAB occurrences, researchers will be able to more accurately predict future outbreaks by using advanced computer models and taking into account the physical and biological conditions leading to HABs" (US Commission on Ocean Policy 2004). Data needed is not limited to "physical and biological conditions," but extends to the economic, sociocultural, and public health dimensions of HAB impacts and their management.

For example, research in economics is critical to assess the effects of HABs on markets in terms of the aggregate level of profits and their distribution, employment, responses of stakeholders to different regulatory approaches, levels of compliance with closures and other harvest constraints, and public health outcomes and the costs of their mitigation.

Sociocultural research is needed to document nutritional, sociocultural (e.g., recreational activities and cultural practices), and economic dependence on resources and activities affected by HABs; identify social networks (i.e., economic, political, cultural, and other relationships) within and across affected sectors and communities; and determine public perceptions of HABs and management (from regulatory policy to education and outreach) to inform mitigation efforts. These kinds of sociocultural information enable managers to more effectively allocate resources to different HAB problems and policy and management approaches.

Data characterizing the potential threats and impacts of HABs on economies, sociocultural values, and public health is critical for effective prevention and response.

Types of data needed to assess the health effects from HABs include environmental characteristics as well as medical and epidemiologic data. Specific components of a database useful for public health decision making include:

- HAB-related environmental data, e.g., water quality, HAB taxonomy, HAB toxin levels, GIS mapping, relevant water characteristics (e.g., tides and color), and other HAB-related events (e.g., fish-kills);
- Human patient data, e.g., demographics, clinical descriptions of signs and symptoms, and laboratory test results;
- Illness outbreak-related data, e.g., medical/clinical data for affected people, and epidemiologic data (e.g., person, time, place characteristics of the outbreak, time from exposure to disease onset, and morbidity and mortality rates); and
- Animal patient data, e.g., demographics clinical data, and laboratory and other test results.

In addition to improved and continuously updated data related to the human dimensions of HAB impacts and their mitigation, the collection of "metadata" is important. That is, it is necessary to assess the data needs themselves and prioritize among different, potentially costly, data gathering ventures so as to maximize the benefits of information collected to policy, management, and community decisions. To be effective, a system of data collection must be a two-stage process: The first stage consists of "scoping" to determine comprehensive data needs and availability. The second stage consists of collecting needed data on a cross-sectoral and ongoing basis.

It is easy to argue that more information about economic, sociocultural and public health dimensions is critical to prevent, manage, and effectively respond to the effects of HABs. However, since the resources required to gather such information on an ongoing basis are scarce, it may be necessary to prioritize among different types of information. Furthermore, it is important to organize the data so that it is readily accessible to those who need it (e.g., affected communities, social service providers, policy makers, and public health providers).

Data needs for HAB mitigation and management are likely to be context-specific in some cases. Therefore, it will be important in most cases to study data needs prior to engaging in costly and time-consuming data collection. Some data needs, and effective methods for satisfying them, will apply to a broader range of contexts. For this reason, one of the research objectives listed below is to understand the applicability of a given set of data needs and techniques to a broader temporal or geographical range of HAB events. This understanding will allow managers to assess where it is especially critical to gather context-specific data and where, by contrast, they can achieve economies of scale by applying data gathered in one place or time to other contexts.

The goals and recommendations in this section are inextricably linked to the other topics in the *Socioeconomic Impacts* section. For example, economic impact assessments (discussed in Section 1.3) require data on market activity, recreational visitation, and public health costs. Any quantitative analysis of trade offs involved in different policy approaches clearly requires data to estimate the relative costs and benefits (for economic, sociocultural, and health-related concerns) of different options.

Research Objectives

1. *Improve understanding of the economic, sociocultural, and public health dimensions of HAB events of different types.*

2. *Characterize the variety of stakeholders (i.e., individuals and communities) affected by HAB events.* For example, stakeholders include commercial shellfish harvesters, managers, and wholesalers; recreational harvesters and those involved in other affected recreational activities such as swimming; communities that are economically dependent upon shellfish harvest, tourism, or other affected industries; tribal members who rely on shellfish for subsistence; community water utilities; and coastal residents and others with cultural ties to affected resources or their harvest.

3. *Characterize the spatial and temporal similarities and differences among HAB events to understand when data collected at one place or time informs understanding and mitigation in other contexts.*

4. *Utilize the outcomes of the preceding objectives to prioritize data collection from different locations and to determine the appropriate spatial and temporal resolution of economic, sociocultural, and public health data collection.*

5. *Develop effective methods for gathering and storing data.* This need is discussed in Sections 2.2 (*Improving Surveillance*) and 2.3 (*Developing Epidemiological Methods*).

6. *Improve understanding of ways in which economic, sociocultural, and public health data will be used by publics, scientists, policymakers, tribal members, managers, and other decision makers to assess and mitigate HAB impacts.* This understanding will enable the design of data distribution mechanisms that maximize the benefits of data, e.g., public forums, web-based dissemination, community and other publications, or publicly available databases.

Example Project

Identifying, Prioritizing, and Implementing Sociocultural, Economic and Public Health Data Collection and Management Relevant to *Pseudo-nitzschia* **Blooms on the Washington Coast**

Description: *Pseudo-nitzschia* produces domoic acid, which is incorporated into the viscera of razor clams and Dungeness crabs, both important commercial and recreational species in coastal Washington. The objective of this project is to identify, provide, and update the sociocultural, economic, and public health data needed to assess and mitigate the impacts of *Pseudo-nitzschia* blooms. This will require data collection in two stages: First, a series of key informant interviews will identify (a) stakeholders, affected markets, and relevant regulations, and (b) the main categories of impacts of blooms and human responses to them. Key informant interviews are in-depth interviews of individuals with valued knowledge about a topic of interest. For example, key informants for this project might include coastal managers, public health professionals, and representatives of affected sectors and communities, including tribes. Second, this project involves the development of a database to store data on public health, sociocultural, and economic impacts and implementation of a data collection process coordinated across sectors.

Methods:

- Archival research to identify historic HAB events; local and regional pathways of exposure to HAB toxins (for example, see Section 2.4, *Identifying Susceptible Populations*); and economic, sociocultural, and public health impacts.
- Ethnographic research to collect case studies informing the development of a database framework. (The term “ethnographic research” refers to a variety of field-based techniques such as interviews and surveys to study a culture).
- A rapid assessment process for collecting data on the economic, sociocultural, and public health impacts of HAB events.
- Evaluation
  - Ongoing communication with and survey of database users (e.g., researchers, public agencies, and policy makers) to determine database utility and modify database design.

- Use of data to test hypotheses such as the extent to which various social groups are susceptible to exposure to HAB toxins.

Outcomes:
- A typology and inventory of stakeholders affected by this type of bloom.
- In the public health dimension, a characterization of the different potential pathways for exposure to domoic acid and their respective health impacts.
- Identification of various data flows, together with an estimate of the cost of gathering data from these sources on an ongoing basis.
- Prioritization of data needs to improve mitigation of the economic, sociocultural, and health impacts of *Pseudo-nitzschia* blooms.

Challenges:
- Providing a database framework that is useful across local and regional scales.
- Prioritizing data needs.
- Quantifying non-market values that are difficult to express in dollar terms such as the emotional trauma caused by HAB illness and recreational pleasure and impacts.

Expertise Needed:
- Economist with expertise in market and non-market valuation techniques, econometrics, and survey design
- Sociologist and Sociocultural Anthropologist
- Database Engineer
- Epidemiologist

Timeline: 6-12 months to establish data needs and design a data collection framework.

Estimated Cost: $200,000

Potential Partners: NOAA, including Sea Grant; universities; local community groups; state health departments; state departments of fish and game; Environmental Protection Agency.

1.2 Assessing Social Impacts

Research Need: Assess the sociocultural impacts of HAB events at local and regional scales.

Lead Author: Linda L. Lampl (Email: llampl@lampl-herbert.com)
Contributor: Dan Ayres

HARRNESS Recommendation: "Compile data and calculate the socioeconomic impacts of HAB events at local and regional scales" (HARRNESS, 55).

Harmful algal blooms can wreak havoc in human coastal communities. For example, during the summer of 2005, a HAB event poisoned clams, oysters, and mussels from Maine to Cape Cod. Massachusetts Governor Mitt Romney reported that this event cost the shellfish industry about $3 million per week (Scheicher, PBS News Hour Extra, 2005). By late summer, inshore fishermen returned to work as the effects of the red tide abated. However, offshore fishermen are still waiting in early 2006 for government regulators to re-open their fishing grounds. Monte Rome, owner of Intershell USA, the largest processor of whole scallops in Massachusetts, stated that his operation is one of the businesses most affected by the lingering closures and observed that the scallop fishermen are "really hurting" (Frazer, Cape Cod Times, 2006).

Yet the human toll of HAB events is more complex than landings data or "multipliers" commonly used to assess economic impacts. In addition to economic impacts, coastal communities can suffer profound social and cultural disruption. On the Pacific coasts of Washington and Oregon, a HAB event caused by the toxin domoic acid forced the closure of the widely popular recreational razor clam fishery in the fall of 2002 (Ayres 2003). State agencies closed these fisheries for over twelve months, resulting in the loss of 400,000 potential clam-digging trips. This government action, necessary to protect human health, also disrupted the long-held recreational traditions of tens of thousands of razor clam enthusiasts from throughout the Pacific Northwest region. In addition, the loss of tourist-related income associated with clam digger visits to small coastal communities resulted in job loss, undetermined social disruption, and an estimated $10 million in lost income.

Similarly, in the Gulf of Mexico in 2005, the seafood community in Franklin County, Florida, an area known for Apalachicola Bay oysters, endured dislocations, personal hardships, and lapses of trust in resource management agencies. The Franklin County oyster fishery lost an estimated $6 million and 1,000 jobs per month in the latter half of the year after regulators closed shellfish harvesting in July and August in response to bacterial problems after Hurricane Dennis and from September to November in response to HABs after Hurricane Katrina (Vail 2005). Some long-term oystering families turned to kinship connections to survive. One woman reported that she shifted "from never borrowing money to having to keep a roof over our heads" (Ritchie, Tallahassee Democrat, 2005). In addition, the traditionally fragile trust between the regulated and the regulating communities floundered. Minimizing the human impacts of HABs requires a solid understanding of the unintended sociocultural consequences of alternative regulatory actions, including methods for communicating warnings and timing of closures (discussed in Section 4, *Risk Communication*). Social impact assessments (SIAs) are needed to provide regulating agencies, tribal and non-tribal coastal communities, and other partners with information necessary to focus response strategies in anticipation of HAB events.

Social Impact Assessment

Regulatory consideration of the social impacts of proposed governmental and private actions emerged with the National Environmental Policy Act of 1969 (NEPA). NEPA requires that federal agencies apply the social sciences to evaluate and consider the direct and indirect social impacts of alternative courses of action. Specifically, NEPA requires federal agencies to:

(A) utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decision making which may have an impact on man's environment; and

(B) identify and develop methods and procedures … which will insure that presently unquantified environmental amenities and values may be given appropriate consideration in decision making along with economic and technical consideration (PL 91-190).

The Council of Environmental Quality promulgated Regulations for Implementing the Procedural Provisions of NEPA that define the "human environment" to include "the natural and physical environment and the relationship of people with that environment." These regulations require federal agencies to assess "aesthetic, historic, cultural, economic, social, or health" effects "whether direct, indirect, or cumulative" (40 CFR 1508.14).

Following these regulations, the Interorganizational Committee on Principles and Guidelines for Social Impact Assessment (ICPGSIA) (2003) defines "social impacts" as "the consequences to human populations of any public or private actions that alter the ways in which people live, work, play, relate to one another, organize to meet their needs and generally cope as members of society. The term also includes cultural impacts involving changes to the norms, values, and beliefs that guide and rationalize their cognition of themselves and their society." The Committee notes that SIAs are to be conducted and alternatives considered during the decision making process and not after the fact to allow for changes in a project or policy:

"Properly done, SIAs help the affected community or communities and the agency to plan for social change resulting from a proposed action or bring forward information leading to reasons not to carry out the proposal" (ICPGSIA 2003).

Today, SIAs are routinely conducted during the proposal phase of private projects and the development of governmental policies, plans, and programs. SIAs prepared since the original NEPA legislation have addressed diverse issues ranging from highways to hous-

> Social impact assessments are needed to provide regulating agencies, tribal and non-tribal coastal communities, and other partners with information to focus response strategies in anticipation of HAB events.

ing, including fisheries and oil and gas development. The basic variables integral to SIAs include, but are not limited to, changes in population, community, and family; community and institutional infrastructures; and political, social, and community resources (ICPG-SIA 2003).

Social Impact Assessment and HABs

Following NEPA, the overarching goal of social impact research related to HABs is to inform coordinated mitigation planning and event response (including education, monitoring, early warning systems, closures, aquaculture techniques for minimizing loss to crops, and other mechanisms) to prevent and respond to human impacts by providing decision makers with information about the ways in which alternative strategies will affect geographic and user communities. To achieve this goal, as discussed below, research is needed to (1) develop baseline and event-specific information on communities that may be directly or indirectly affected by toxins, marine animal mortalities, and/or governmental intervention; (2) develop Rapid Assessment techniques for immediate deployment in HAB events; and (3) collect baseline information on institutional arrangements and regulating communities within which governmental decisions are made.

Definition of Social Impacts

"Consequences for the ways in which people live, work, play, relate to one another, organize to meet their needs and generally cope as members of society. The term also includes cultural impacts involving changes to the norms, values, and beliefs that guide and rationalize their cognition of themselves and thier society" (ICPGSIA 2003).

Research Objectives 1

Rapid Impact Assessment

1. *Develop data-based knowledge of the complex communities commonly located in coastal or near-coastal areas.*

   a. Develop Rapid Assessment methods suitable for profiling communities prior to, during, and after a HAB event or series of HAB events.

   b. Develop individual community profiles that can be used as a baseline by federal, regional, state, and local (tribal and non-tribal) decision makers to craft NEPA-type management alternatives, including a "no action" option.

Identification of the community as a unit of analysis presents a methodological challenge, particularly in the increasingly developed or urbanized coastal areas of the US. For example, Miami-Dade County in Southeast Florida is comprised of 31 municipalities and a myriad of smaller collections of human groups that may be divided by ethnicity, more than 50 languages, socioeconomic factors, and/or occupation. In addition, consideration of impacts to temporary residents, tourists, and seasonal occupants requires non-traditional definitions of community.

The complexity and richness of these human connections can be best understood through the perspectives and methods of anthropology, sociology, psychology, economics, and other social sciences. Rapid Assessment methods may be crafted for use specifically for HAB events (or other coastal hazards). Baseline profiles that consider and map the interactions and expectations of permanent and short-term residents, among other social dimensions, can be developed and maintained as a database by which changes resulting from HAB events and their management can be predicted and assessed.

Example Project 1

Predicting HAB-Related Social Impacts in Coastal Communities: Developing and Testing Rapid Assessment Methods

Description: The objective of this project is to develop and ground truth HAB-specific Rapid Assessment methods in three communities, making resulting data available for use by federal, regional, state, and local (tribal and non-tribal) leaders responsible for decision making in anticipation of or response to HAB-related events. This pilot project is intended to develop and test Rapid Assessment methods for collecting baseline and event-specific data on social changes that occur in response to a HAB event or series of events in coastal and/or near-coastal communities. The project could focus on three coastal communities, enabling comparison of impacts.

Phase 1 would develop a set of Rapid Assessment methods, establish HAB-focused research questions, and develop preliminary baseline information on social characteristics. Methods would draw from existing Rapid Assessment approaches to create a research design appropriate for HAB events and utilize coastal resource management community studies to develop baseline information. Phase 2 would pilot test the Rapid Assessment methods to create profiles of three communities. Phase 3 research would conduct SIA in response to an actual HAB event. Researchers would enter the field at the onset of the HAB event and return six months after the HAB event. The project would provide: (1) a field-tested Rapid Assessment methodology and (2) baseline and HAB-specific data for three communities. The data will inform allocation of resources and development of strategies to protect public health, economic interests, and communities.

Methods: Qualitative and quantitative methods including but not limited to:
- Literature Review
- Document Analysis
- Ethnographic Fieldwork
- Observation (participant and non-participant)
- Focus Group Interviews
- Key Informant Interviews
- Surveys

Outcomes:
- Field-tested set of Rapid Assessment methods for application in HAB events.
- Emergent library of cases that can be used to create data-based options for governmental and community decisions in anticipation of or response to HAB events.
- Assessment of the sociocultural impacts of HAB events in three communities.

Challenges:
- Establishing trust between researchers and communities.

Expertise Needed:
- Anthropologists
- Ethnographers
- Sociologists
- Psychologists
- Economists
- Translators/Interpreters

Timeline: 12-18 months.

Estimated Cost: Project costs are necessary to cover the following expenses:
- Staff
  - Principal Investigator — 1 part-time
  - Community Researchers — 3 part-time
  - Graduate Student Support — 2 part-time
- Equipment
  - 3 Tablet /Laptop Computers
- Expenses
  - Travel and Per Diem

Research Objectives 2

Integrating Human Dimensions Data into HAB Research and Response

1. *Conduct an analysis of the federal, regional, state, local, and tribal governmental and non-governmental organizations responsible for closures, warnings, and other actions undertaken to minimize risks and respond to impacts associated with HABs*.

   a. Develop a context map or other tool for understanding and representing points of articulation in decision making processes.

   b. Identify challenges and strategies for integrating human dimensions data (such as the economic, sociocultural, and public health data needs identified in Section 1.1) into HAB research programs and decision processes. Lack of public trust in resource management agencies and inexperience of HAB researchers with social data are two possible challenges.

Example Project 2

Integrating Human Dimensions Data into HAB Research and Response

Description: This project will inventory decision making organizations and points of articulation in federal, state, local, and tribal decision making communities with resulting data available for use prior to and during HAB events. Based on this inventory, the goal is to identify opportunities to facilitate integration of human dimensions data into HAB decision making processes. A multi-agency program for human dimensions research modeled after the Ecology and Oceanography of Harmful Algal Blooms (ECOHAB) program could facilitate data collection, sharing, and use (see Recommendation 1.2)

The project would be conducted in two phases. Phase 1 would inventory policy, management, research, public, tribal and other partners integral to decision processes for HAB response. Phase 2 would develop and maintain knowledge of the network of organizations and individuals integral to detection, analysis, prediction, and management of HAB outbreaks and their impacts. These data could be used as a baseline to monitor the regulatory process and to identify points of entry for inclusion of critical human dimensions data such as the economic, sociocultural and public health parameters identified in Section 1.1. Additionally, the data may suggest opportunities for, and benefits or challenges of, specialized training for natural scientists in social science approaches or opportunities for interdisciplinary connection for natural and social scientists.

1.3 Assessing Economic Impacts

Research Need: Assess the economic impacts of HAB events at local and regional scales.

Lead Authors: Porter Hoagland (Email: phoagland@whoi.edu)
Contributor: Guillermo Herrera

HARRNESS Recommendation: "Compile data and calculate the socioeconomic impacts of HAB events at local and regional scales" (HARRNESS, 55).

A first step toward improved understanding and managing HABs is an assessment of their economic, sociocultural, and public health effects. There are well-established methods for estimating the economic damages associated with natural hazards such as HABs. Such methods quantify changes in economic welfare that are reflected in both established markets, where goods and services are traded at a price, and activities and resource uses, such as swimming, that are not directly traded in markets.

Market-based welfare measures quantify the net benefits to parties on both sides of market transactions, i.e., the benefits that consumers enjoy in excess of what they pay for goods and services (called "consumer surplus") in addition to the revenues that producers earn in excess of their production costs (called "producer surplus"). For example, closure of a commercial shellfishery due to a HAB event could reduce the surplus earned by commercial fishermen. However, affected fishermen may compensate for lost revenue by transferring their fishing effort to areas that remain open or switching to non-fishing activities to earn income. An accurate estimation of the economic impacts of the HAB event would account for the income earned through such compensation measures, capturing the net loss (or possibly gain) of revenue to commercial fishermen.

Economists rely upon consumer expenditures as data to help estimate the value of non-market goods and services, such as the cultural value of recreational shellfishing or experience of beach visitation. For example, the "travel cost" method of non-market valuation expresses the economic value of an environmental area (such as a beach popular for swimming) in terms of the amount of money that individuals are willing to spend to visit it (see Lipton et al. 1995).

While economists prefer to focus on net benefits, changes in total sales (i.e., revenues) are simpler to

> Implementing management measures to mitigate the economic impacts of HAB events always involves economic trade offs. The purpose of economic analysis is to make these trade-offs explicit and to express them in a common metric.

calculate and provide an upper bound on the changes in net benefits to producers. A variety of formulas are used to determine changes in total sales from HAB-related shellfish closures. Unfortunately, many of these calculations are not useful for making normative management decisions about how best to respond to HABs.

Beyond measuring effects in the market as a whole, policy makers are also concerned with measures of changes in employment, and in characterizing who benefits (if anyone) and who loses as a result of a HAB event. These effects are known generally as distributional economic impacts. In order to decide between different approaches to responding to HAB events, it is important to fully characterize the implications of each potential management approach. These implications include the economic effects on different sectors of the economy (e.g., commercial shellfish harvesters and processors, the tourist industry, and agricultural producers) and consumers in these sectors, public health impacts, and sociocultural impacts on communities (for example, family stress resulting from changes in income distribution or disruption to social networks). The choice between different management approaches to HAB events will likely involve trade offs among these impacts.

For example, the management of a HAB event involving commercially harvested shellfish involves implicit trade offs between public health risks and forgone profit in the fishery. While policy makers may be loathe to put a dollar value on human morbidity or mortality, the choice of a threshold level of a toxin used in closure decisions involves an implicit willingness to accept some impacts to public health for profits, or vice-versa. This trade off can be expressed as the "value of a statistical life" or morbidity changes can be accounted for by the use of a measure such as "quality-adjusted life years" (QALYs).

The role of anthropogenic factors in the incidence, severity, and duration of HAB events is uncertain. To the extent that anthropogenic factors do contribute to HAB events, however, there are trade offs relevant to this interaction as well. For example, if nutrient runoff from agriculture contributes to the formation of a bloom that leads to beach closures, management should consider not only the trade off between risk of illness and forgone recreational values, but also the impacts of constraining the scale of the agricultural industry or their choice of fertilizers, among other effects of management strategies.

The choice of spatial scale is also important for the analysis of trade offs. Closure of a beach, for example, has local costs (e.g., loss of recreational benefits) and benefits (e.g., reduced health risk), but may also affect neighboring communities (e.g., through changes in visitation).

Research Objectives

1. *Identify the location, type, and spatial and temporal scales of HAB events*. The first need is to characterize the physical natural hazard.

2 . *Identify affected markets and nonmarket activities*. The second need is to characterize the relevant affected market(s) and valued activities that occur outside of market institutions.

3. *Characterize the economic impacts of HAB events*. Analytical efforts ought to be devoted to the most serious hazard events. Rough economic impact estimates based upon changes in total sales revenues may be useful as a preliminary criterion in deciding whether or not to proceed with an economic study. For example, a one-time HAB event leading to damages on the order of $2-5 million might not warrant the time and effort of an economic analysis.

4. *Estimate economic welfare changes resulting from HAB events*. The most relevant measure of economic impacts looks at changes in consumer and producer surpluses (described above) as a consequence of the natural hazard. It is appropriate to use surplus changes to help scale appropriate policy responses.

5. *Describe potential policy measures, both qualitatively and quantitatively.* An important need is to

identify the universe of feasible policy responses or management measures. In this group, the option of doing nothing ("living with it") must be included. The cost of implementing policy measures at a range of scales should be calculated.

6. *Identify potentially affected economic sectors and consumer groups*. If decision makers are concerned with the distributional economic impacts on industry sectors or consumer groups, information about these sectors and groups should be compiled. Information on distributional impacts can inform the efforts of other social scientists engaged in HAB-related studies such as social impact assessment (Section 1.2), community vulnerability assessment (Section 1.4), identification of human populations susceptible to exposure (Section 2.4), and risk communication (Section 4).

7. *Qualitatively describe the nature of the economic effects*. If a project aims to describe distributional economic impacts, it is important to characterize the scale of economic effects on each of the affected sectors or groups of interest.

8. *Where both sides of a trade off can be measured in financial terms, make dollar-based comparisons of the implied trade offs*. Implementing management measures to mitigate the economic impacts of HAB events always involves economic trade offs because management measures are costly. The purpose of economic analysis is to make these trade offs explicit and to express them in a common metric.

9. *Where both sides of a trade off cannot be measured in financial terms, estimate the implicit prices of objectives that are not conventionally expressed in dollar terms*. The implicit price of an amenity reflects its effect on the overall price of some good or service. For example, a quality ocean view may carry a high implicit price relative to the overall cost of coastal housing. A view of waters recurrently affected by HABs may reduce this economic value. In many cases, where market data is unavailable or highly uncertain, it may be feasible to estimate an "implicit" price for environmental goods or services. These prices should be used to assess the relevant trade offs.

10. *Where relevant, consider trade offs across space (e.g., between communities or states), over time, among industry sectors or consumer groups, and among social groups such as recreational and tribal communities*. If decision makers are concerned with distributional economic impacts, the trade offs should be characterized across spatial and temporal scales and across industries and consumers. In many cases, this part of the analysis will be of the greatest interest to policy makers.

Example Project

Management of PSP Outbreaks in the Gulf of Maine

Description: Shellfish closures in the coastal waters of the Gulf of Maine during the 2005 outbreak of *Alexandrium fundyense*.

Methods:
- Models of supply and demand in local or regional shellfish markets.
- Accounting for the cost of alternative management measures.
- Nonmarket valuation methods for environmental goods and services.

Outcomes:
- Model to optimize the application of policy responses to HAB events. Model could be used to simulate alternative courses of action in anticipation of or response to HAB events.

Challenges:
- Lack of historical data on shellfish prices and quantities
- Estimating non-market values

Expertise Needed:
- Microeconomic theory
- Econometric analysis
- Policy analysis

Timeline: One to two years.

Estimated Cost: $75,000-$200,000, depending on the scale and scope of the study. Labor costs are predominant.

1.4 Assessing Community Vulnerability

Research Need: Assess the vulnerability of actual and potential HAB-affected communities to sociocultural and economic impacts of HAB events.

Lead Author: Bill Wood (Email: woodww@cwu.edu)
Contributor: Caroline Pomeroy

HARRNESS Recommendation: HARRNESS (page 57) establishes the need to identify populations susceptible to public health impacts "based upon physiological traits, behavioral factors, socioeconomic status, and cultural practices." Section 2.4, *Identifying Susceptible Populations*, provides research objectives and an example project to meet this need.

Similarly, identifying groups at increased risk of sociocultural and economic impacts is important to focus prevention and response strategies. This section emphasizes the importance of assessing the vulnerability of groups to sociocultural and economic impacts as part of a comprehensive assessment of community vulnerability. Assessing the vulnerability of communities recurrently or potentially affected by HABs to all impacts – public health, sociocultural, economic, and environmental – is important to focus coordinated prevention and response efforts by federal, state, local, and other (tribal and non-tribal) partners.

Vulnerability refers to the "characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard" such as a HAB event. Key variables explaining variations of impact (to hazards generally) include class, occupation, caste, ethnicity, gender, disability and health status, age and immigration status (whether 'legal' or 'illegal'), and the nature and extent of social networks." Assessing the vulnerability of communities to public health, sociocultural, and economic impacts of extreme natural events, including HABs, is important because these impacts "occur when natural hazards affect vulnerable people" (Wisner et al. 2005). Community vulnerability assessment is a systematic way of focusing prevention and response efforts on critical needs and high-risk segments of populations, and providing a baseline for evaluation of local and regional mitigation strategies.

> **Definition of Vulnerability**
>
> "Characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard" such as a HAB event (Wisner et al. 2005).

Assessments of sociocultural and economic vulnerability provide a demographic-based snapshot of the beliefs, attitudes, practices, and other characteristics of individuals and groups that put them at differential risk of sociocultural and economic harms as a result of HAB events and responses. Such characteristics include beliefs about the predictability of coastal hazards such as HABs, attitudes toward resource management and public health agencies, cultural practices tied to potentially affected marine resources, access to HAB-related outreach information and educational programming, and reliance on potentially affected marine resources for subsistence. For example, groups that utilize affected resources such as razor clams for subsistence may not only be at relatively great risk of HAB-related illness (as described in Section 2.4, *Identifying Susceptible Populations*), but may also be especially vulnerable to social disruption (such as stress in family relationships or increased dependence on kin groups or social services for nutrition) when that subsistence base is threatened. Similarly, groups that rely on the existence or use of potentially affected marine resources to retain economic self-sufficiency and cultural autonomy (such as the Makah and the Quinault tribes in Washington) may be especially vulnerable to cultural loss and social conflict during and after HAB events (Olympic Region Harmful Algal Bloom Partnership, www.orhab.org/impacts/index.html).

Research Objectives

Before providing research objectives, it will help to explain a few premises underlying assessments of community vulnerability to sociocultural and economic impacts. First, the term community can be used to encompass not only geographically and politically delineated areas (such as regions, municipalities and townships), but also stakeholder groups defined by interests or resource uses (such as marina operators and commercial fishermen) and subpopulations (such as social groups defined by culture or immigration status). Second, an assessment of a community's vulnerability does not imply a negative judgment of its demographic profile, cultural beliefs, or other characteristics, but offers a scientific assessment of its capacity to prevent and recover from sociocultural, economic, or other impacts. Third, a broad spectrum of social science research methods are useful for vulnerability assessment. These may include, but are not limited to, surveys, analysis of secondary survey data such as the US census, analysis of narrative and image content (e.g., public health programming materials or mass media communications), rapid ethnographic assessment (such as the example project described in Section 1.2, *Assessing Social Impacts*) and participant observation, photo and video documentation, GIS tracking and mapping, and structured interviews.

The following community profile approach illustrates the basic information critical to assess the vulnerability of a generic community to sociocultural and economic impacts associated with HAB events. For more information on community vulnerability assessment to support hazard mitigation planning, the H. John Heinz III Center for Science, Economics, and the Environment (2000) provides a general framework for assessing physical, sociocultural, economic, and environmental vulnerability at the community level. NOAA's Coastal Services Center developed a methodology for community vulnerability assessment and case study based on this framework (http://www.csc.noaa.gov/products/nchaz/htm/prodes.htm).

1. *Develop a community profile describing:*

   a. *Demographic attributes such as age, gender, racial structure, occupations, income level, family size, education levels, and primary languages*. Profiles of communities recurrently or potentially affected by HABs will inform future monitoring efforts by establishing a demographic baseline against which to track changes resulting from HAB events or responses. Tracking such changes is an important part of longitudinal studies seeking to understand how long-term historical changes in impacts of HAB events correlate with demographic changes over time. For example, historical changes in family structure and the employment of women in the workforce may have a significant impact on the extent to which HAB-triggered underemployment in commercial fishing, an industry predominantly employing males, contributes to economic hardship and social disruption for families.

   b. *In-group and wider community social networks and relationships that may influence the vulnerability of segments of the community to sociocultural and economic impacts of HABs*. Understanding how social networks and relationships (such as church-based support groups and multigenerational extended family structures) reduce or amplify the socioeconomic risks of HABs throughout a community (e.g., through pooling resources) is critical to inform mitigation efforts. Such networks and relationships include political, economic, religious, family, and ethnic or racial affiliations and associations. For example, a church community that is recognized by the larger community as a source of food donations during emergencies could be an important resource to help local officials reach families affected by HAB events to provide them with public assistance and other forms of relief.

   c. *Activities of community members and others that may influence vulnerability during or after a HAB event*. Understanding the behavior of community members (and the behavior of non-community members with connections to community members) is an important part of assessing the vulnerability of different groups to HAB events. For example, recreational activities in marine environments during a HAB event increase vulnerability to illnesses that may, in turn, increase absenteeism at work, decrease worker productivity, and thereby result in economic losses and social conflict. Assessments of sociocultural vulnerability should describe such risk-amplifying activities and map their occurrence to inform resource management agencies, government assistance programs, tribal leaders, and other decision makers of the multiple activities that place communities at greater socioeconomic risk.

d. *Attitudes and beliefs (knowledge) of community members that may influence vulnerability to sociocultural and economic impacts of HABs*. For example, risk-relevant beliefs include judgments about areas where exposure to toxins during HAB events is likely, mechanisms of exposure, symptoms and treatment of HAB illnesses, and the predictability of coastal hazards such as HABs. Relevant attitudes include the level of trust in coastal resource management agencies. For example, an individual who believes that HABs are unpredictable may be less likely to comply with beach closures and thus more likely to be exposed to HAB toxins while swimming or engaging in other recreational activities. Understanding attitudes and beliefs of potentially affected community members related to HAB events is necessary to identify the root causes and motivations for behaviors that increase the risk of sociocultural, economic, or health-related impacts. Only by accommodating or modifying such behaviors through prevention strategies (e.g., monitoring, education, warning information, and closures) can risks be avoided. Scientific documentation of attitudes and beliefs that influence community vulnerability is critical to enable decision makers to focus prevention and mitigation strategies on underlying causes of impacts.

Example Project

Assessing Latin American Immigrant Community Vulnerability to Sociocultural and Economic Impacts of HABs in the Chesapeake Bay Watershed

Description: Latin American immigrants are an increasing segment of the population in and around the Chesapeake Bay. Drawn to the area for work primarily in the agriculture (e.g., chicken processing) and service (e.g., construction) industries, many are members of families with small children, live dispersed across the rural Maryland, Delaware, and Virginia countryside, face language barriers (many are monolingual Spanish speakers), and are relatively unfamiliar with the public health infrastructure of the US. The short-term nature of their employment, lack of access to public services, and other factors may make Latin American immigrants especially vulnerable to sociocultural and economic impacts during and as a result of HAB events.

This project will provide a baseline assessment of a narrow and poorly understood range of behaviors and knowledge of the Chesapeake Bay Latin American immigrant community in relation to HAB events. It focuses on the sociocultural and economic implications of recreational fishing on the Eastern Shore of Maryland on the Delmarva Peninsula from Kent Island South to Taylor's Island (from approximately the Bay Bridge south to the Blackwater National Wildlife Refuge) and associated consumption of fish and seafood. Very little is known about the recreational behaviors of Latin American immigrant populations in general and still less is known about how those recreational behaviors focused on marine environments may put them at risk to suffer sociocultural and economic hardships as a consequence of a HAB event. Additionally, very little is known about the degree to which recreational fishing articulates with informal economic activities and the degree to which seafood caught by recreational fishermen is distributed and consumed by other segments of the community, and in other areas, through family relationships, ties to informal businesses, and other social networks.

The project is divided into four phases:

- Phase 1 includes (a) a review of existing survey data provided by the US census to describe demographic characteristics of the Latin American immigrant community combined with (b) rapid ethnographic assessments of known recreational fishing areas along Maryland's Eastern Shore as described above. (The term "ethnographic research" refers to a variety of field-based techniques such as interviews and surveys to study a culture).

- Phase 2 emphasizes the collection of survey and key informant interview data describing Latin American immigrant recreational fishing activities and knowledge at select locations (ideally, at least one seafood collection and fishing area each in the Eastern Bay, Choptank and Little Choptank).
- Phase 3 traces connections between recreation activities at those select locations and the consumption of seafood within the Latin American immigrant community as well as connections to the wider community, including the circumstances under and ways in which seafood caught by immigrants is purchased and consumed.
- Phase 4 focuses on the interpretation of data, including statistical analysis, mapping by geographic area and activity, and content analysis of interview transcripts.

Methods: Surveys, interviews, participant observation, rapid ethnographic assessment, photo and video documentation, GIS mapping and imaging.

Outcomes:

- An assessment of recreational fishing and consumption patterns in the Latin American immigrant community of the Delmarva Peninsula that influence their vulnerability to sociocultural and economic impacts of HAB events.
- A profile of the demographic characteristics of the Latin American immigrant community that engages in recreational fishing (as well as of groups of people who consume the fish they catch).
- Description/map of where, and how, seafood caught/collected along a significant segment of Maryland's Eastern Shore enters the informal and/or formal economy and is purchased and consumed throughout the wider community.
- Snapshot of where and how Latin American immigrants currently practice recreational fishing (i.e., their behavior).
- Description of the beliefs and knowledge of Latin American immigrant recreational fishermen.

Challenges: Because many recent Latin American immigrants are undocumented and live relatively mobile lives, there are special challenges associated with this project. For instance, there is a growing anti-immigrant sentiment throughout the US (especially of undocumented, Spanish-speaking immigrants from Latin America). As a result, immigrants may be less likely or less willing to talk with investigators, making it challenging to access the community and establish the trust and rapport necessary to collect data. This challenge is likely to be aggravated by the population's mobility because individuals on the move will be unlikely to provide information about their whereabouts with community members and/or research teams.

Expertise Needed:

- Some combination of demographers, ethnographers, and sociologists with Spanish language abilities, knowledge of the history and culture of Latin America and the history of Latin American immigration to the US, and familiarity with statistical packages (e.g., SPSS) and GIS software (e.g., ARCVIEW).
- Marine biologists capable of identifying seafood caught/gathered.

Timeline: Since recreational fishing activities in and around the Chesapeake Bay are seasonal, research will take place over a multi-year period (minimally 2 years) in order to account for variation in the behavior and use of resources.

Estimated Cost:
Phase 1: $40,000
Phases 2 and 3: $65,000- $175,000 (depending on the number of localities)
Phase 4: $15,000

Additional Projects: Ideally, similar follow-up projects would be conducted throughout the Chesapeake. Bay watershed and include urban areas (such as Baltimore, Annapolis, and Virginia Beach).

1.5 Assessing Economic Benefits of Forecasts

Research Need: Conduct socioeconomic studies of how user groups will benefit from HAB forecasts at different temporal and regional scales.

Lead Author: Porter Hoagland (Email: phoagland@whoi.edu)
Contributor: Guillermo Herrera

HARRNESS Recommendation: Same (HARRNESS, 55).

Policy makers, natural resource managers, research scientists, industry officials, the media, and the public now widely recognize that HABs can result in serious economic impacts on a variety of coastal businesses and users of the ocean. Although economic impacts from this kind of natural hazard clearly exist, only a few studies have attempted to document these impacts or to report them on a comparable and consistent basis. In the future, in order to scale levels of investment in the science and management of HABs, it will be important to refine estimates of the nature and size of economic impacts (see Section 1.3, *Assessing Economic Impacts*). Documentation of sociocultural impacts (discussed in Section 1.2, *Assessing Social Impacts*) is also critical.

For many industries and users of the coastal ocean, there may be value in the development of a capability for predicting or forecasting the occurrence of HABs. This value arises from the possibility that some or all of the damages caused by HABs might be averted through advance knowledge about the likelihood of the occurrence of an event and actions that can be taken to mitigate the potential damages. Industries potentially affected by HABs include wild harvesters of shellfish, shellfish growers, and businesses such as hotels, restaurants, and others who are dependent upon coastal tourism. Coastal tourists, who are consumers of environmental goods and services such as clean air, clean beaches, and recreational fishing also may be harmed by HAB events.

Public officials have begun to develop an interest in building regional capacities for predicting HAB events. This interest is reflected in agency budgets and sponsored research on the science relating to the factors that contribute to bloom formation, transport, and fate. Coupled biophysical models useful for predicting blooms are now under development for the Gulf of Maine, the Gulf of Mexico, and the Pacific Northwest. These models are necessary but not sufficient for predicting the economic effects of HAB events.

A well-established "value of information" framework is commonly used to assess the economic value of predictions of future conditions. Using this approach, the value of HAB predictions to firms or individuals is given by the expected difference between the economic surplus that results when the prediction is used in decision making (i.e., the dollar value of the public health and sociocultural benefits of the prediction minus the costs of producing and delivering it) and the surplus that results when the prediction is not considered (i.e., the dollar value of public health and socioeconomic costs). Assessments of the economic value of HAB forecasts are important for federal and state governmental agencies to leverage and justify investments of public dollars in their development and use.

Research Objectives

1. *Analyze the economic impacts of the status quo (i.e., in the absence of forecasting models)*. The first objective is to measure the economic impacts of HAB events in the absence of prediction, using a model of firm or individual behavior.

2. *Assign probabilities to the occurrence of a HAB event*. The second objective is to characterize the prediction itself in terms of the occurrence or non-occurrence of an event within a specified time period. The value of HAB prediction will depend on the accuracy or "skill" of the prediction.

3. *Identify the range of feasible responses of public and private decision makers, given that a HAB event has been predicted*. The third objective is to begin to develop a model of economic behavior to examine how decisions would be made in light of a HAB prediction with given characteristics. This step typically involves identifying a range of potential responses by public and private decision makers (e.g., beach goers and tourism operators) to mitigate economic damages.

4. *Characterize the economic effects of alternative responses*. Using the behavioral model, this objective involves the evaluation of the economic consequences – both costs and benefits – of the choice of a particular response for a decision maker. Decision makers are assumed to choose the response that leads to the greatest net present value or utility.

5. *Aggregate the value of individual decisions. It is important to point out that the value of prediction to society, as opposed to the individual decision maker, will be the product of decisions made by many individual decision makers*. A fifth objective would involve the development of a model that can be used to aggregate the decisions of firms and individuals into an overall measure of prediction value.

Example Project

Economic and Public Health Benefits of Predicting Red Tides along the Florida Gulf Coast

Description: Develop a framework for estimating the economic value of predicting (forecasting) blooms of *Karenia breve* along the west coast of Florida in the Gulf of Mexico. The model would rely upon estimates of the economic damages associated with respiratory illnesses that are caused by a bloom that occurs near the coast. (Other categories of economic damages, including losses to the tourist industry, shellfish bed closures, or non-market losses arising from takes of manatees, might also be incorporated into such an analysis.)

Methods:
- Estimates of cost-of-illness or non-market morbidity costs (e.g., pain and suffering) for respiratory ailments in Florida
- Estimates of the increased incidence of respiratory ailments as a consequence of a HAB event
- Identification of mitigation measures and their costs (e.g., public health alerts, avoiding beaches, and rescheduling vacations)

Outcomes: A model to estimate the value of forecasts to individuals to mitigate the medical costs of a *Karenia* bloom. The model could be used to evaluate alternative courses of action. Results of the model can be aggregated to obtain an overall value of a predictive capability.

Challenges:
- Development of predictive model of bloom formation, transport, and fate
- Estimates of cost-of-illness
- Estimates of non-market morbidity costs

Expertise Needed:
- Microeconomic theory
- Econometric analysis
- Policy analysis
- Risk assessment

Timeline: One to two years.

Estimated Cost: $100,000-$350,000, depending upon the scale and scope of the study. Labor costs are predominant.

2. Public Health Impacts

This section builds on the "Impacts of HABs on Public Health" section of HARRNESS (page 57), discussing the following research topics and needs (Fig. 8).

Public Health Impacts – Research Topics and Needs

2.1 Developing Diagnostic Tools
Research Need: Conduct assessments of public health professionals, public service groups, and other sectors that respond to HAB poisonings, and utilize their feedback, to develop tools for clinical diagnostic support and transition them to operation.

2.2 Improving Surveillance
Research Need: Improve surveillance of human exposure and disease.

2.3 Developing Epidemiological Methods
Research Need: Develop new, cost effective epidemiological methods appropriate to HAB issues that will enhance capacity to develop primary public health and prevention activities.

2.4 Identifying Susceptible Populations
Research Need: Identify susceptible populations based on characteristics such as physiological traits, behavioral factors, socioeconomic status, and cultural practices.

Figure 8. Public Health Impacts - Research Topics and Needs

2.1 Developing Diagnostic Tools

Research Need: Conduct assessments of public health professionals, public service groups, and other sectors that respond to HAB poisonings, and utilize their feedback, to develop tools for clinical diagnostic support and transition them to operation.

Lead Author: Susan Lovelace (Email: Susan.Lovelace@noaa.gov)
Contributor: Lorraine Backer

HARRNESS Recommendation: "Develop tools for clinical diagnostic support" (HARRNESS, 57).

In their report to Congress providing recommendations for a new and comprehensive national ocean policy, *An Ocean Blueprint for the 21st Century* (2004), the US Commission on Ocean Policy recognizes the need to "support the development of improved methods for monitoring and identifying pathogens and chemical toxins in ocean and coastal waters and organisms." Such methods are to include "new tools for measuring human and environmental health indicators in the marine environment" and "models and strategies for predicting and mitigating harmful algal blooms." In the same year, this critical need was echoed by the passing of the Oceans and Human Health Act (OHH Act), which establishes a national research program to improve understanding of the role of the oceans in human health.

Building on *Ocean Blueprint* and the OHH Act, HARRNESS recognizes that "there are no readily available tools or methods for diagnosing HAB-related illness in humans or animals. Thus, accurate diagnosis, treatment, and prognosis are impossible" (HARRNESS 2005, 57). Consequently, documented cases of HAB-related poisonings likely represent only a small portion of those that actually occur. To improve diagnosis and reporting, and thereby understand and reduce impacts of HABs on human health, HARRNESS recommends the development of tools for clinical diagnostic support. For example, a diagnostic decision-support software program could be made available to public health professionals and regularly updated to incorporate new information on HAB-related illnesses. Alternatively, a diagnostic keycard would enhance ease of use and maximize access by a diversity of responders. Similarly, a simple informational card summarizing HAB-related illnesses and symptoms might facilitate recognition and appropriate response by high-risk groups such as recreational fishermen, beach goers, and public service groups such as lifeguards, hotel operators, and coastal resource managers. Another critical need is for development of assays for biological effects of these toxins. These assays could be in the form of biological markers of exposure (i.e., toxin concentrations in urine, blood, or other biological specimens) or of effect (e.g., changes in a clinical blood parameter that is specific to a particular toxin). Laboratory assays that confirm exposure would enhance correct diagnosis and the ability to prevent further illnesses. Finally, we cannot improve HAB-related illness diagnosis until there is some consensus on case definitions. Using what we know about the symptoms associated with exposures to HAB-related toxins to identify what would likely be the clinical presentations of people with HAB-related illnesses would provide physicians with a basis for accurate diagnoses.

Like any product, developing, prototyping, and evaluating tools to connect HAB science to diagnostic decisions requires a good understanding of and collaboration with their potential users. Important considerations include user preferences (e.g., media type), knowledge (e.g., familiarity with vectors and symptoms of HAB illness), and perceptions (e.g., of the seriousness of HAB illnesses) as well as the environment in which the tool will be used (e.g., hospital laboratory, private medical office, or in the field). For example, if it turns out that public health professionals have relatively little understanding of exposure pathways – e.g., consumption of contaminated food or water, or inhalation of aerosolized toxins – then a diagnostic tool developed for their use must convey this information in order to facilitate diagnosis, reporting, and treatment of HAB-related poisonings. Similarly, if medical professionals in a HAB-affected locality view HAB-related illnesses as minimally serious, effective diagnosis and treatment could be aided by integrating or pairing a diagnostic tool with communications emphasizing potentially severe symptoms such as liver failure where high concentrations of cyanobacterial toxins contaminate drinking water.

Building on the HARRNESS recommendation to develop diagnostic tools, the research objectives below emphasize the need to build bridges between users and producers of such tools to ensure their effective design and delivery. Research on the preferences, knowledge, perceptions, use-environments, and other characteristics of potential users such as public health professionals and public service groups (called "user assessment") is critical to develop tools that are specific for the exposures of concern and promote accurate diagnosis and effective treatment. Focus groups involving potential users are also critical to test prototypes, and education is needed to transition tools to operation in clinical and community settings.

> Effective design and delivery of diagnostic tools requires research on user characteristics, focus groups to test prototypes, and education to transition tools to operation.

Research Objectives

1. *Identify categories of public health professionals, public service groups, resource managers, and other sectors that are integral to responding to, reporting cases of, diagnosing, and treating HAB-related poisonings.*
2. *Assess preferences, knowledge, perceptions, and other characteristics of these user communities that may influence product design.*
3. *Define the scope and sequence of information to be produced by diagnostic tools and determine effective methods for risk communication given cultural, educational and socioeconomic diversity of coastal areas and user groups.*
4. *Incorporate feedback from user communities on product prototypes to maximize support in efficiently and effectively responding to, reporting cases of, diagnosing, and treating HAB-related poisonings.*
5. *Utilize educational and outreach programming to facilitate effective transfer of diagnostic tools for use in clinical, beach-side, household and other settings.*
6. *Evaluate effectiveness of clinical diagnostic tools through surveys to obtain user feedback.*

These objectives outline a step-by-step process for tool development and delivery that includes learning about local medical institutions, tourism operators, and other groups that provide care for individuals experiencing symptoms, assessing characteristics of such responders to inform the development of prototypes utilizing up-to-date information on toxins and their effects, testing prototypes by incorporating user feedback, and facilitating the use of products in various settings through educational programming.

Example Project

Assessing the Needs of Medical Health Professionals for Tools to Support Diagnosis of HAB Illnesses

Description: Following Objectives (1) and (2) above, the overarching goal of this project is to identify informational, technological, and other needs of public health professionals to ensure that tools developed are maximally effective in promoting accurate diagnosis and effective treatment. Subsequent funding and continued work would be necessary to develop prototypes, test them by incorporating feedback from the public health community, facilitate their use through educational programming, and evaluate their effectiveness for facilitating diagnosis, reporting and treatment of HAB-related illnesses.

Methods:

- Surveys, semi-structured interviews with key informants, and focus groups to assess the preferences, knowledge, and perceptions – as well as HAB diagnostic needs and ease-of-use information about various diagnostic schemes – of groups of public health professionals that may differ with respect to these characteristics, e.g., emergency responders, community health clinicians, private physicians, hospital administrators, beach managers, life guards, and emergency medical technicians.

- Interpretation of survey, interview, and focus group results to identify needs of public health professionals for diagnostic tools to facilitate accurate diagnosis and effective treatment of HAB-related illnesses – including HAB information (e.g., methods of exposure and types of toxins), medical information (symptoms characteristic of various illnesses), and technological requirements (e.g., preferred media or format such as a diagnostic tree).

Outcomes:

- Identification of informational and technological needs for tools to assist public health professionals in diagnosing HAB-related illnesses.

Challenges: Engaging public health professionals in survey response and focus groups.

Timeline: Approximately one year. Phase One – project planning, survey development, focus group planning. Phase Two – survey, interview, and focus group implementation, data analysis.

Expertise Needed:

- HAB Toxicologist
- Epidemiologist
- Sociologist

> While the technical challenges of a Harmful Algal Bloom Information System (HABIS) are significant, equally challenging is the need to understand stakeholder needs and requirements in order to ensure that data are captured in the most efficient and accurate manner possible.

Estimated Cost: \$50,000 - \$75,000, including part-time salary of \$25,000 for principal investigator; graduate student stipend of \$12,000; travel and other expenses associated with focus groups, surveys, and interviews; and supplies.

Potential Partners: Centers for Disease Control and Prevention, state and local health departments, local chapters of American Red Cross, lung health organizations, marine laboratories, and medical schools.

2.2 Improving Surveillance

Research Need: Improve surveillance of human exposure and disease.

Lead Author: George Luber (Email: gcl4@cdc.gov)

HARRNESS Recommendation: Same (HARRNESS, 57).

The prevalence of human illness due to exposure to HABs is not well understood, primarily due to the lack of human cases identified and reported to state and local health departments. This is in part a result of failure to link health effects with exposure pathways (e.g., swimming, boating, or fishing), but is also likely the result of the lack of a uniform and accessible manner for reporting potential human and animal illnesses associated with HABs. There is a critical need to develop a reporting system for state and local health officials that can facilitate the collection and dissemination of reports of possible human and animal cases of HAB-related illness.

Responding to this need, federal and state public health officials have developed an online reporting system for HAB-related illnesses that is designed to combine human and veterinary case information and environmental data relevant to HABs in one location. The Harmful Algal Bloom Information System (HABIS) is a secure, web-based system that allows state health and environmental departments to enter and update information related to cases status, HAB environmental factors, and associated animal illnesses or deaths.

While the technical challenges of such a system are significant, equally challenging is the need to understand stakeholder needs and requirements in order to ensure that data are captured in the most efficient and accurate manner possible. We propose undertaking a rapid ethnographic assessment of stakeholder, or end-user, perceptions of barriers and facilitators to the successful implementation of the HABIS surveillance system. This formative research will help ensure that the proposed surveillance system will provide an accurate picture of the true burden of disease posed by HABs.

Research Objectives

1. *Identify stakeholder perceptions of barriers and facilitators to the successful implementation of the HABIS surveillance system.*

2. *Identify additional sources of information that can assist in reporting HAB cases. These might include sportfishing and recreational groups such as birdwatchers, boaters, and wildlife enthusiasts.*

Example Project

Rapid Ethnographic Assessment of Stakeholder Acceptance of the HABIS Surveillance System

Description: This project will explore stakeholder and "end-user" perceptions of barriers and facilitators to using an electronic web-based system like HABIS for the collection and dissemination of information pertinent to human and animal illnesses related to HAB exposures.

Methods: This project employs a Rapid Ethnographic Assessment (REA) methodology which relies primarily on a qualitative approach. The REA approach is designed to be adaptive and iterative, relying on the refinement or revision of questionnaires and focal domains as the research progresses. The REA approach relies on the flexible use of a variety of approaches, including focus groups, key informant interviews, semi-structured and unstructured interviews, and participant observation. At the core of the approach is that the investigator begins with a limited set of predefined domains that are explored and elucidated in a time-limited manner.

Outcomes: This assessment is designed to assist in the development of the HABIS system and will ultimately be evaluated by the number of users, the frequency of use, and the quality of the data that is entered into the system.

Challenges: Close collaboration and buy-in from state and local health departments, environmental protection officials, and private veterinarians is key to gaining access to stakeholder perceptions.

Expertise Needed:
- An investigator familiar with the collection and analysis of qualitative data is essential. In addition, as this is an iterative methodology, expertise in a variety of ethnographic methods would be ideal (i.e., participant observation, focus groups, pile-sorts, triads testing, and cognitive domain elicitation).
- Close collaboration and buy-in from state and local health departments, environmental protection officials and private veterinarians would be key to gaining access to stakeholder perceptions.

Timeline: The REA approach is intended to be formative in nature and guide the development of the final HABIS product. Therefore, the REA should be conducted over a time period of no greater than one month.

Estimated Cost: Fieldwork expenses, travel, and transcription costs should not exceed $20,000.

2.3 Developing Epidemiological Methods

Research Need: Develop new, cost effective epidemiological methods appropriate to HAB issues that will enhance capacity to develop primary public health and prevention activities.

Lead Author: Lorraine Backer (Email: lbacker@cdc.gov)

HARRNESS Recommendation: "Develop new, cost-effective epidemiological methods that are appropriate to HAB issues" (HARRNESS, 57).

Traditional epidemiologic methods available to investigate environmental health issues are labor intensive, expensive, and time-consuming. Case definitions for HAB-related illnesses vary from agency to agency or are simply nonexistent. There is typically no way to clinically verify HAB-related exposures or illnesses. Also, there are no resources to conduct the prospective studies needed to fully assess the chronic effects from acute or chronic exposures to HABs and HAB-related toxins. Identifying and applying alternative methods for data collection and analysis will enhance our ability to develop timely and effective public health activities and exposure- and disease-prevention strategies.

Research Objectives

1. *Investigate or develop alternative strategies for case-reporting, including those that do not require the patient to interact with the medical community.* Additional case-finding would help the public health community identify the individual variations in response to toxins and help assess true disease incidence. It would also help public health agencies target response and prevention activities.
2. *Develop alternative methods to analyze and present environmental data that provide the public with information they can understand, accept, and use to make personal decisions about potential exposures*. There should be some consistent response to HAB-associated events that those responsible for communicating with the public develop and agree to disseminate.

Identifying and applying alternative methods for data collection and analysis will facilitate timely and effective public health activities and exposure- and disease-prevention strategies.

Example Project 1

Use of Alternative Data Sources for HABs-Related Illness Reporting

Description: The objective of this project would be to examine whether HAB-related illness data from alternative (non-medical) sources (e.g., beach volunteer organizations and the hospitality industry) would be valuable in assessing the extent of the effects of HABs on public health. This is currently a source of "anecdotal" data that could provide information about people who get sick from HABs, and complain about it, but do not interact with the local community – making their illness impossible to capture via the medical community.

Methods: Investigators would provide hotels and restaurants or volunteer organizations that monitor beaches with very simple data-collection instruments that they can use and return to local public health authorities.

Outcome: Determine the number of people who have symptoms they believe are associated with HAB-related exposures (e.g., aerosolized Florida red tide toxins) and find out whether they ever engage with any part of the health care system for their illness. This is another component of the effects of HABs on people.

Challenges:

- Members of the hospitality industry are not always willing to bring up issues that may adversely affect their businesses.
- People may feel uncomfortable reporting illnesses to someone at a hotel or restaurant. To overcome this challenge, the survey could be a post-paid card that they could drop in the mail.
- The data could be biased because of the association with the hospitality industry (who want the problem to go away) or beach volunteers (who may have advocacy roles).

Expertise Needed: Investigators would need to collaborate with representatives from the hospitality industry, public outreach, and public education. For the epidemiologic work, investigators would need to collaborate with the medical community (someone who is familiar with the types of illnesses that might be reported), local health agencies, and statisticians.

Timeline: This activity should be done over several seasons to collect data under varying potential exposures.

Estimated Cost: This project should not be too costly. It would be an appropriate and valuable project for a Masters in Public Health (done over 2 years).

Potential Partners:
•Schools of public health (support for study projects)
•Fellowship programs (e.g., an Oak Ridge Institute for Science and Education (ORISE) fellowship at the Centers for Disease Control and Prevention (CDC)

Example Project 2

Alternative Methods to Develop Public Health Messages

Description: This project could use focus groups or other methods to assess what type of environmental data (e.g., *Karenia brevis* cell counts, level of microcystins in recreational lake) people feel comfortable using to make personal decisions about exposures (e.g., to swim or not to swim).

Methods: Small groups of people of different ages and backgrounds, etc., can be asked to examine different types of messages and explain how they develop their responses to the messages. (For discussion of message development, see Section 4, *Risk Communication*).

Outcome: Gain insight into how people process scientific data and use it to make personal decisions.

Challenges: It may be difficult to identify focus group participants because, in many geographic areas, these issues (e.g., red tides in Florida and blooms off the coast of the Northwest US) are contentious.

Expertise: The expertise needed for this project would include a Sociologist or Anthropologist, expert on what types of HAB data are available, specialist in public outreach and education, public health professional or other individual familiar with the HAB-related illnesses, local health agency, and Statistician.

Timeline: One year.

Estimated Cost: Full-time fellowship and part of a statistician's time for a year.

Funding Sources: This could be a graduate student project in a school of public health or communications department, or be accomplished through a fellowship program (such as ORISE at CDC).

2.4 Identifying Susceptible Populations

Research Need: Identify susceptible populations based on characteristics such as physiological traits, behavioral factors, socioeconomic status and cultural practices.

Lead Author: Caroline Pomeroy (Email: cmpomeroy@ucdavis.edu)
Contributor: George Luber

HARRNESS Recommendation: Same (HARRNESS, 57).

Toxins in the marine environment pose significant threats to human as well as ecosystem health. HABs are a source of toxins in the world's oceans, and are increasingly reported in coastal waters throughout the US. One significant route of human exposure to HABs is the consumption of contaminated seafood. There is a critical need to determine the potential human health threat posed by consumption of HAB-contaminated seafood and to develop socio-culturally appropriate means for reducing that exposure.

Several recent seafood consumption studies document relatively high consumption levels and exposure to pollutants among certain socio-culturally and economically defined groups of anglers (e.g., West et al. 1992, Allen et al. 1996, Connelley et al. 1996, Asian Pacific Environmental Network 1998, San Francisco Estuary Institute 2000). The Office of Environmental Health Hazard and Assessment (2001) provides a review of many of these studies. However, little has been done to determine consumption patterns of seafood contaminated with naturally occurring toxins produced by some phytoplankton species that cause HABs. Identifying susceptible populations by investigating specific risk factors such as physiological traits, behavioral factors, socioeconomic status and cultural practices (such as species harvested and methods of food preparation) are critical to enable public health and fisheries officials to focus exposure prevention strategies and outreach efforts.

Identifying susceptible populations by investigating specific risk factors such as physiological traits, behavioral factors, socioeconomic status and cultural practices (e.g., species harvested and methods of food preparation) are critical to enable public health and fisheries officials to focus exposure prevention strategies.

Research Objectives

The primary objective is to develop and field test a methodology that utilizes ethnographic and survey field research to identify:

- subpopulations at increased risk of exposure to HAB toxins;
- the social, cultural, and economic networks through which potentially contaminated seafood is distributed for consumption;
- the social, cultural, economic, and nutritional values attached to the consumption of these species (especially when prepared in ways that retain the toxin); and
- the mechanisms and institutions through which members of at-risk subpopulations exchange information.

Ultimately, it is hoped that this methodology can be adapted to different exposure scenarios, e.g., those that do not involve consumption of seafood, but nevertheless expose certain groups to HAB toxins.

Example Project

Identifying Populations Susceptible to HABs and their Impacts through their Consumption of Contaminated Seafood

Description: This project uses a combination of ethnographic and field survey research methods to identify and characterize socio-culturally and economically distinct subpopulations whose consumption patterns (i.e., species targeted and preparation techniques) of angler-caught fish puts them at greater risk for exposure to HAB toxins.

Hypotheses to be tested include:

- Fishing and consumption patterns will differ among socially-, culturally-, and economically-defined subpopulations of anglers.

- The fish consumption patterns of some of these subpopulations will put them at greater risk of exposure to HAB toxins than anglers overall.
- The high risk of exposure to HAB-related toxins will occur also among family and friends of anglers from these subpopulations.

Methods: Preliminary archival and ethnographic research will define the social, cultural, and ecological context of fishery and community structures of potentially at-risk subpopulations in the selected region. Intercept surveys will collect data from anglers on their social, cultural, and economic characteristics; their fish catch, disposition, and consumption patterns; and their motivations for catching and consuming species known or likely to be HAB toxin vectors. An evaluation component will compare the seafood consumption survey sample to population estimates from other sources (e.g., Marine Recreational Fisheries Statistical Survey and US Census) to determine the representativeness of the sample and enable inferences about risk of exposure to the larger angling population.

Outcomes:
- Identification of the relevant social, cultural, and economic risk factors of subpopulations that have a potential for high of exposure to HABs and their toxins;
- An inventory of salient social and economic relationships between community groups that can be used as a resource for monitoring, communicating, and exchanging HAB-related information; and
- Field testing of a method for identifying susceptible subpopulations, which can be adapted based on exposure pathway.

Challenges: A key challenge will be achieving effective cross-cultural communication with individuals and groups that may be wary of, or sensitive to, questioning of their activity patterns. Gaining their trust and cooperation might require time. In addition, it is essential to avoiding causing alarm among anglers and the larger public, especially if it leads to unnecessary avoidance of fish as a source of nutrition. Given the likely low level of exposure to the population as a whole, but the possible high level exposure by some groups, considerable data collection effort and careful statistical work will be required to insure the robustness of the data and analyses.

Expertise Needed:
- Sociocultural anthropologist or sociologist
- Team of interviewers fluent in the target language(s) and culture(s)
- Biological oceanographer or fisheries biologist knowledgeable of potentially contaminated species
- Statistician to assist with sampling design and analysis of complex multivariate survey data
- Community education and outreach specialist

Timeline: Two years

Estimated Cost: $120,000 for a single port area (i.e., up to 6 discrete fishing locations).

Potential Partners:
- Sea Grant
- Public and private universities
- Local community groups
- State health department
- State departments of fish and game
- NOAA National Marine Fisheries Service
- Philanthropic organizations that support research on women's, children's and/or under-served populations' nutritional and general health, environmental justice, etc.
- EPA

Additional Projects: Follow-on projects could include:

a) identifying and characterizing subpopulations of non-anglers who consume potentially contaminated fish sold, bartered or shared by anglers,

b) determining social, cultural and economic motivations for and dependence on consuming HAB-affected species,

c) identifying social networks, and opportunities and constraints to collecting exposure and impact information from, and disseminating information to, those subpopulations.

3. Recreational and Drinking Water Impacts

This section combines discussion of the following research topics and needs established in the "Recreational and Drinking Water" section of HARRNESS (Fig. 11).

3.1 Improve Monitoring and Documentation
Research Need: Expand and improve systematic monitoring and documentation of the occurrence of algal toxins in drinking and recreational waters.

3.2 Develop Short-Term Response Plans
Research Need: Develop short-term response plans for algal-contaminated water to protect public health.

3.3 Develop Water Quality Standards
Research Need: Incorporate algal toxins into water quality standards for drinking and recreational waters.

Figure 9. Recreational and Drinking Water Impacts - Research Topics and Needs

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HARRNESS Recommendations: Same (HARRNESS, 58).

HARRNESS notes that "the abundant growth of cyanobacteria in reservoirs contributes to significant practical problems for water supplies. Moreover, many of the known cyanotoxins (e.g., microcystins and saxitoxins) have been associated with deleterious health effects. The full impact of the presence of these toxins on contaminated water bodies remains unknown." Although "surveys conducted in the US have identified algal toxins in drinking water and recreational waters … there is no ongoing systematic monitoring program in place to identify high-risk areas." Moreover, "water utility managers and those responsible for recreational water quality do not have water quality standards on which to base decisions for safe levels and practices. Therefore, water users are not necessarily protected from exposures and subsequent related health effects" (HARRNESS 2005, 58).

Social science is critical to improve monitoring, documentation, and response strategies to reduce the impacts of algal toxins in drinking and recreational waters. For example, surveys of water management agencies are needed to determine perceived needs for response plans and develop models for effective interagency coordination.

The need for clean drinking and recreational waters is especially critical for health issues, but quality of life issues are also important. In addition to causing health problems ranging from mild discomfort to life-threatening, HABs create significant problems of a socioeconomic nature. The costs of water quality monitoring will ultimately be born by the general public, adding another economic consideration. Availability of clean water is typically considered to be a right of the general public, but municipal water systems are increasingly managed through contracts to private firms. In effect, responsibilities for water management and impacts of contamination cut across private and public domains. Recreation in coastal waters may also be seen as a public right, but infrastructure is largely provided by privately-owned businesses. The private and public domains are cross-cut there also, creating complexity in monitoring and response.

Social and biological science are both necessary to improve monitoring, documentation, and response to algal toxins in drinking and recreational waters. As described below, social science research objectives are especially needed.

Research Objectives

An introductory note about social science research methods may be useful. Since social science research focuses on characteristics of social groups, including knowledge, perceptions, and values shared by their members, careful attention has to be given to identification and measurement of variables that are culturally relevant (Weller and Romney 1988, Sobo and de Munck 1998, Ryan and Bernard 2000, Bernard 2006). The concern is that representation of shared information (i.e., culture) must have internal validity. That is, social research methods such as surveys and interviews must reflect the categories and content specific to a social group's culture (Romney, Weller, and Batchelder 1986; Strauss and Quinn 1997; Blount 2002; Quinn 2005). Assumptions by researchers that culture is known prior to designing and implementing a study will likely lead to imposition and utilization of incorrect or erroneous categories, thereby producing biased results. Preliminary research to elicit and identify cultural content is an absolute necessity if internal validity is to be attained. Research instruments, especially formal surveys, must be derived from social science inquiry that grounds them relative to the relevant social group's knowledge and experience (Blount and Gezon 2003).

The procedures used in preliminary research will essentially be the same for each research objective below, although the details may vary from objective to objective. In each case, information about knowledge, perceptions, and other characteristics is sought from individuals within the social group in order to identify information shared across members. The procedures involve ethnography (informal and formal interviews) and focus group discussions, followed by draft descriptions of analyzed patterns of shared information presented to other interviewees or discussion groups for their feedback (e.g., corrections and amplifications) (Johnson 1999, Bernard 2006, Garcia-Quijano 2006). The results can then serve as background information to the construction of more formal research methods – typically, surveys to elicit information from larger samples within the population (Blount 2004). These may be more or less standard socioeconomic surveys, but modified by the results of the preliminary research. Sampling should be done according to characteristics of each social group, but in most cases, sampling will be systematic.

Since these preliminary/exploratory steps in social science research are fundamental to each objective below, they can be assumed to be present and thus do not need to be repeated.

1. *Survey water resource managers and others responsible for the quality of drinking and recreational waters in order to identify current and projected monitoring, documentation, and response practices*. The research to meet this objective would include questions about current monitoring, documentation, and response systems, but the thrust would be to ascertain perceived needs for improved methods. The research would document the extent to which HABs are viewed by water resource managers and other key organizations as current health problems and the problems perceived to result from increased occurrence. The survey could be regional and inclusive of all management agencies and organizations, providing a comprehensive account of the perception and understanding of HABs and the needs for monitoring, documentation and response. Systematic sampling of agencies and organizations could be applied to larger coastal areas, e.g., deriving samples from cities in the Gulf Coast states and then generalizing to the entire US Gulf Coast.

2. *Identify and describe public perceptions of algal toxins and their harmful effects in drinking and recreational waters*. This should be a large scale project comparing sample populations (e.g., townships and communities) in areas previously

affected by HABs to populations in unaffected areas. The comparative samples will (a) document public perceptions of HABs and their impacts, and other related variables, prior to any experience with HABs (called “perception baselines”) and (b) describe changes in perception baselines as a result of experience with HABs. In both instances, results would describe public understanding, gaps in public knowledge, level of trust in water utility and coastal resource management agencies, and other important variables. In the case of (b), the molding of perceptions by experience with HAB events might reveal dimensions of public perception that inform systematic monitoring, documentation, and response strategies. Case studies in affected communities could begin to yield profiles of the types and extent of socioeconomic impacts preliminary to developing guides of likely consequences when HABs occur in new areas.

For example, four townships or communities could be selected for comparison: one as a control in which there has been no history of impacts from HABs on drinking water or recreational water, one in which HAB events have impacted drinking water, one in which HAB events have impacted recreational water, and one in which HAB events have impacted both drinking and recreational water. The comparisons would reveal changes in public understanding and perception as a result of experience with HAB events, thereby informing strategies for stakeholder involvement and outreach integral to monitoring, documentation, and response. To illustrate, if results show that communities recurrently affected by HABs tend to have relatively little trust in warnings issued by coastal resource management agencies, then research on building trust (see Section 4, *Risk Communication*) may be a critical component of response planning.

3. *Identify and describe the nature and extent of public support for increased monitoring of public water supplies and water management strategies to protect against HABs*. The same sample areas and town/community samples could be used to describe and elicit public support for increased monitoring. Recent surveys on water quality reflect a diminishing confidence in the quality of public water supplies, reinforced by massive advertising to convince the public that commercial, bottled water is safer and by the increasing number of reports of problems with the safety of public water systems. This diminution of support and the willingness of populations to support increased monitoring and documentation, both in terms of regulations and financial costs, would be measured. Opposition to water additives has always been present among some members of the general public, and surveys would need to measure support for any new additives to control quality, should those be necessary. A particularly useful approach would be a study of a community recently affected by HABs to ascertain whether, and the extent to which, experience of impacts increased public awareness of and sensitivity to the need for increased protection. The responses could be used to inform the construction of surveys for communities with no history of exposure.

4. *Identify and describe the public's perception and understanding of the need to monitor and regulate activities that are known to produce or exacerbate HABs*. National and global expansion of HABs is considered to be partly a result of human activities such as changes in agricultural and aquaculture practices that increase nutrient loading, overfishing, and ballast water discharge (HARRNESS 2005, 9). If regulatory strategies for preventing and controlling HABs are to successfully restrict such activities and thereby control HABs, then it is important to document the public's understanding of the need for such restrictions and willingness to comply with alternative regulatory and enforcement mechanisms. Research is necessary to document related beliefs and perceptions in communities (a) recurrently affected, (b) briefly and infrequently exposed, and (c) never exposed to HABs. One outcome would be improved understanding of the role and value of public experience in developing and enforcing regulatory strategies to prevent and manage impacts of HABs.

5. *Survey water resource managers and organizations in areas recurrently or potentially affected by HABs to (a) describe existing monitoring and response plans and perceived needs for improve-*

ment and (b) identify areas where no plans have been developed and assess perceived needs for development. The research would seek information as to whether monitoring and response plans were developed and implemented after HAB events, both to assess perceptions of their success and to elicit needs for more effective planning. The research would attempt to identify conditions under which agencies would see the need to develop short-term response plans. It would also assess the feasibility of and identify models for interagency coordination on local and regional scales. A major goal of research on this objective would be documentation and assessment of actual experiences, providing historical models.

6. *Survey water resource managers and organizations to identify whether they would be willing to incorporate algal toxin information into drinking and recreational water quality documentation*. This research would assess whether water resource agencies see a need to incorporate algal toxin information into descriptions and reports about water quality, how the information should be expressed if a perceived need exists, and what the consequences would be in terms of public perceptions and responses. A trade off might exist between the public perception of health protection and an increase in governmental warnings and regulations, affecting the ways in which agencies might wish to proceed. An especially important research project would be the identification of health, economic, and sociocultural consequences of HABs and prediction of what information would have been the most educational to help plan for and alleviate them. Selection of information could be based on instances in which harmful effects were actually present and required amelioration.

7. *Identify models that address regulatory, institutional, and citizenry involvement and assess the advantages and disadvantages of each type, for (a) public water supply and (b) recreational water availability and use*. The survey in this instance would be of examples of managerial systems in areas prone to HABs. The units would be public or private organizations responsible for water management, and the research would focus initially on the ways in which the units address regulations, institutional activities, and citizenry involvement and input. Once types of management-sponsored involvement are identified, surveys would need to be developed that address perceptions of the relative strengths and value of each type, including problem areas or topics. Input would be solicited to assess major considerations to each type of involvement and desirable outcomes expected. The example project below provides an instance of how research on this objective might be designed.

Example Project

Perceptions of HABs in Corpus Christi Bay Recreational Waters: Informing Management and Education

The Texas Gulf Coast is lined with a number of large inland bays. From the upper coast southwestward to Mexico, these are Galveston Bay, Lavaca/Matagorda Bays, San Antonio Bay, Copano/Aransas/Redfish Bays, Corpus Christi Bay, Nueces Bay, and Baffin Bay. Although these bays share common characteristics, each bay has different environmental and social features, depending on a number of factors such as amount of surrounding wetlands, rainfall and vegetation patterns, and surrounding human population. Galveston Bay is surrounded by large population centers that number collectively in the millions, whereas the other bays have much smaller but rapidly growing populations. Galveston Bay is also surrounded by the giant southeastern Texas petrochemical industries, and it includes Buffalo Bayou and the Houston ship channel and port. Research on water issues in the industrial, urban areas of Galveston Bay would be more complex and on different scales than the lower part of the Bay and the other bays to the southwest. The particular bay chosen for the example project, Corpus Christi Bay, is the most urban of the bays other than Galveston, but on a much smaller scale. Research issues would be similar to those of the other bays, even the lower Galveston Bay.

Description: The project aim is to describe perceptions held by three categories of recreational users of Corpus Christi Bay of threats from HABs to the water quality of the Bay and its associated impact on recreation. The three categories are: (1) tourists who use the bay for recreation, specifically fishing and boating; (2) residents of the two urban areas, Corpus Christi and Ingleside, who use the Bay or are engaged in activities that relate directly to the Bay (fish houses, commercial fishers, seafood restaurants); and (3) officials of recreational organizations. The latter include the Packery Channel Park, the Redhead Pond Wildlife Management Area, the Corpus Christi Botanical Gardens, the Hans A. Suter Wildlife Park, the Texas A&M University-Corpus Christi Nature Trail, and the Indian Point Park/Sunset Lake Hike and Bike Trail.

Methods: Officials representing each of the organizations will be interviewed about pollution problems in the Bay, sources of point and non-point source pollution (especially estuarine problems from agricultural runoff into the Nueces River), the increasing impact on the Bay from urban population growth, and the possible negative impacts from pollution and other extreme natural events, including HABs. They will also be asked what they believe (1) tourists and residents know about pollution and about HABs and (2) tourists and residents should know, i.e., what should be more widely known. The perspectives shared by officials will serve to construct questions for preliminary research with tourists and residents. The pilot study will be ethnographic (i.e., informal interviews and focus groups), leading to construction of preliminary questionnaires. The questionnaires will also be tested prior to development of a formal questionnaire as the research instrument, which will be administered directly by interviewers.

Outcomes: The questionnaires will serve as databases for statistical analyses to produce profiles of perception type, their frequencies, and levels of significance. The results will be expected to show where gaps in knowledge and misunderstandings are the more striking and in need of education.

Challenges: The major challenge is expected to derive from the paucity of knowledge about pollution effects and HABs on the part of the recreational sector. Administration of questionnaires directly by individuals is intended to counter what would be very low response to mail or telephone interviews.

Expertise Needed:
- Anthropologist
- Sociologist,
- Environmental/Marine Scientist
- Statistician

Timeline: The project would require two years, 18 months for data collection and six months for data analysis and final report.

Estimated Cost: $250,000. The major expense would be salary for personnel, including the project coordinator/principal investigator and graduate student assistants to help with the data collection and analysis. The second major expense would be for research costs at field sites, i.e., for per diem and travel.

4. Risk Communication

Protecting public health, coastal communities, and coastal and linked economies requires promoting behaviors that reduce vulnerabilities and promote recovery from impacts of HABs. Such “risk-wise” behaviors include participating in volunteer phytoplankton monitoring efforts, complying with beach closures and fish consumption advisories, and reporting and treating HAB-related illnesses. HARRNESS affirms the importance of education and outreach, especially communications focused on susceptible populations such as those subsistent on local seafood, “to ensure accurate knowledge, attitudes, and perceptions” fundamental to such “risk-wise” behaviors (HARRNESS 2005, 65). Risk communication is a field of social science that promotes effective communication by scientists, resource managers, educators, community leaders, and others toward this end.

Research Need: Risk communication research assisting scientists, resource managers, educators, community leaders, and others in focusing communications to promote public behaviors that reduce vulnerability and respond to impacts of HABs.

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Contributor: Dan Ayres

HARRNESS Recommendation: While HARRNESS does not explicitly recommend risk communication research, the insights of this field are critical to achieve one of its goals – focusing outreach and educational communications to promote “risk-wise” public behaviors, thereby protecting public health, coastal communities, and coastal and linked economies.

A growing and major challenge faced by resource management, public health, and other agencies is the communication of increasingly complex science to publics who may be disinterested until they are negatively impacted. In a technologically advanced democracy, citizens risk becoming disenfranchised on an increasing number of issues characterized by complex scientific and technical information. The fact is, there is a general lack of understanding in the public sector regarding the mathematical probabilities that are inherent in scientific and technical information such as HAB forecasting models. Consequently, as the information revolution continues to accelerate, it becomes increasingly clear that more information does not result in better informed citizens empowered to prevent and respond to the impacts of extreme natural events such as HABs. Conversely, providing the public with too much information can lead to “information overload,” which can be as ineffective as not providing enough.

Areas of Risk Communication Research

- Organizational Trust
- Risk Perceptions
- Social Amplification of Risk
- Mass Media
- Message Development and Design
- Communication Strategies

Areas of Risk Communication Research

Risk communication is a field of social science that focuses on six needs critical to improve the effectiveness of organizations at communicating complex science to policy makers, stakeholders and interested citizens: building organizational trust, understanding risk perceptions, understanding social amplification of risk, improving mass media communications, developing communication messages, and developing communication strategies. These needs cut across organizations charged with protecting societal objectives such as public health and ecosystem function. They also cut across natural resource and hazard management issues facing such organizations. To prevent and respond to impacts of any hazard, both internal and external audiences need appropriate, timely and clear information about actual and probable impacts, and appropriate responses. Organizations need detailed information about how their interested audiences understand, perceive, react to, behave and use information related to science, warnings, forecasts, and hazards. Ineffective communication about risk situations can increase harm to citizens, increase concern or fear needlessly, lead to inappropriate behaviors, and decrease trust in agencies, which can further decrease agency effectiveness.

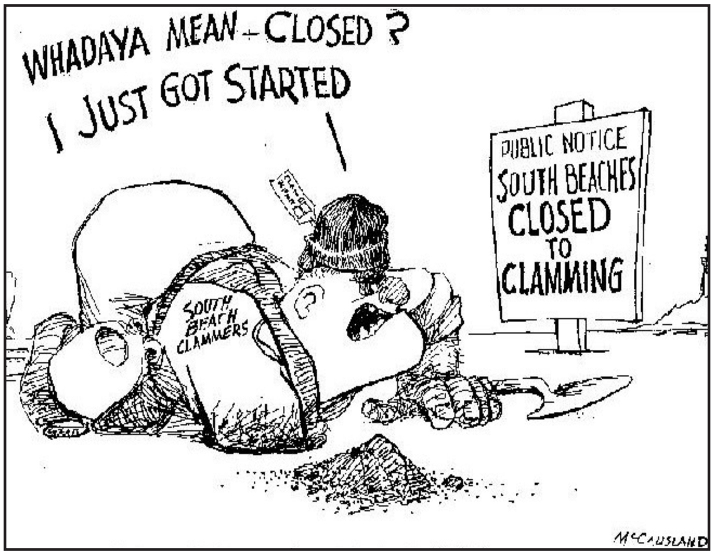
1. Building Organizational Trust. Building trust is the fundamental focus of risk communication. Trust is characterized by a number of features, including perceived competence, objectivity, fairness, consistency, and goodwill. Risk information sources, such as government agencies, need to understand that trust is a very important factor in the acceptance and effectiveness of risk-based messages to the public. Most research confirms that government agencies are in fact considered by the public to be a less-than-trusted source of risk information. The public tends to view government risk-based information as distorted, biased and probably incorrect. The effectiveness of government agencies as sources of information and risk communicators suffers from the lack of trust in its messages and is further aggravated by the public's increased worry about risk (Foster 2000).

Risk communication research is critical to help scientists, coastal resource managers, water utility managers, public health authorities, and others communicate forecasting and other information so that the public understands the probability of a HAB event, trusts the message, and responds in ways that reduce vulnerabilities and promote recovery from impacts.

For example, along the US West Coast, state agencies do a good job of protecting the health of those who wish to harvest shellfish species prone to marine toxin exposure, especially domoic acid. Extensive toxin testing is conducted prior to and during any shellfishery opening. Testing has limited the incidence of human illness to only a few minor cases and prevented any deaths associated with this dangerous toxin. This testing and the states' strict adherence to federally established action levels have also resulted in numerous fishery closures that have in some cases lasted more than a year. Frustration over these closures and the fact that there have been very minor, if any health impacts has led to a general level of disbelief and distrust of the agencies. From the perspective of coastal resource managers, this lack of confidence is a puzzling result of the successful protection of the very people who don't believe they need protection. Such lack of confidence illustrates that maintenance of trust must be a priority in the design of any risk communication strategy. Agencies face several challenges in the area of trust and credibility, not only because they are already perceived to be a less trusted source, but also because they sometimes discourage public participation in decision making processes (Renn 1998).

The other side of the trust issue pertains to resource management and other experts, who are also prone to the same biases as the general public. For example, experts sometimes view the public as: 1) incapable of grasping complex issues, 2) incapable of forming relevant views, 3) believing anything they read in newspapers, 4) holding opinions shaped by narrow, selfish concerns, 5) apathetic, and, 6) unwilling to take the time or trouble to consider anything that does not affect them directly. In short, the public is often perceived by agencies as gullible, selfish, and irresponsible.

It is vital, therefore, for agencies to incorporate information on audience perceptions of science and risk in their programs and activities as they relate to the development, management and communication of scientific and technical information. Recognizing trust as an important aspect of risk communication is only one step toward establishing the practical operational aspects of what an institution must do to increase the public's trust and confidence in it. More often than not, governments are called upon to inform and reassure individuals about risks that are unknowable, unpredictable and about which the experts disagree. Some suggest that scientific uncertainty has a tendency to politicize risk, changing the nature of the engagement between experts, politicians and the public to one in which trust becomes a pivotal element (Coote and Franklin 1999). A correlation between trust and credibility and risk perceptions has suggested that when trust or credibility is lacking, people perceive greater risks. Public meetings, used in many risk situations, can be critical in setting the stage for understanding and believing hazards. Research can address how



Bob McCausland, The Daily World, Aberdeen, WA

dialogue and consideration of alternatives can promote more informed decisions about risk behaviors.

2. Understanding Risk Perceptions. Research in this area is primarily designed to help agencies better understand how stakeholders and other audiences understand, perceive, and behave toward specific sociocultural, public health, economic, or environmental hazards. Information from these studies is particularly useful in organizational decision making about how to better address concerns of affected audiences. In some cases, audiences may misunderstand complex scientific and technical information. In others, stakeholders may need additional or different information in helping them make rational choices. Information on risk perceptions can help agencies determine agency needs for research, audience needs for information, and appropriate methods of delivering complex information to meet target audience needs.

For example, public meetings called to discuss a marine toxin related fishery closure are often characterized by polar perceptions of risk. Some insist that HABs are “not a real problem” and express a strong preference for fishery and health managers to let them “take their chances” by engaging in risk-prone harvesting and recreational activities. Others express extreme fear of exposure to toxins and seek government reassurance that there is no risk before they are willing to participate in any harvest or recreational activities.

Agencies also face pressures emergent with the evolution of the “information society.” For example, people are better educated and have greater access to information through vehicles such as the internet and 24-hour news. A better informed and educated public is far less likely to accept direction from authority without question when it affects their day-to-day lives. For example, the public is becoming increasingly aware of risks to the food supply and is demanding more information.

3. Social Amplification of Risk. Risk events pertaining to hazards interact with psychological, social, institutional, and cultural processes in ways that can heighten or attenuate perceptions of risk and shape risk behaviors. Behavioral responses, in turn, generate secondary sociocultural and economic consequences. Consequences of HABs and other coastal hazards extend beyond human health to include impacts such as liability, insurance costs, loss of confidence in institutions, stigmatization, cultural loss, and alienation from community affairs. Individuals, groups, the media, and institutions become amplification stations. Agencies need to understand how their activities and communications amplify hazards (Kasperson 1992).

4. Mass Media. How messages are formulated and delivered to the mass media by coastal resource managers, public health authorities, and others can influence how the media cover a HAB event or other hazard. The media, in turn, play an important role in risk communication and the formation of public concerns, beliefs and behaviors. Despite its importance in shaping public risk perceptions and behaviors, the extent of the media’s impact on public perception and management of risk remains somewhat of a mystery and is the subject of much ongoing research. Research in this area may involve analysis of how the media are covering hazard events, and how agencies and organizations are providing messages to the media. Risk communication researchers also provide training for agency personnel on effective communication of risks to the mass media.

It is widely accepted that the media are not only an important source of risk information to the public, but also play a role in bringing issues to their attention, fueling a sense of public urgency. Journalists are not educators or, at least, this is not their primary role. From this perspective, it is not surprising that media coverage seldom results in more than cursory coverage of an issue, contributing little if anything to the more complicated process of working through the problems. News coverage that presents positions as adversarial often actually retards progress towards dealing meaningfully with issues. The adversarial position rarely corresponds to the real views of most people. This is a style of communication which rarely comes close to true risk communication. The media tend to highlight existing concerns, uncertainties and conflicts, rarely questioning the legitimacy of any source, and presenting all sources on a rather equal footing. In this sense, the media's role might be considered to be "non-judgmental." Information is provided to the public with little or no analysis of its technical accuracy (Friedman 1986).

5. Message Development and Design. The presentation of a risk message can significantly influence the public's understanding of risks associated with HABs or other extreme natural events. For example, different ways of framing messages can lead to vastly different public perceptions and behaviors. People will use their own frames of reference to define issues, often resulting in completely different understanding. Providing scientific and technical information, for example, has been found to not always change target audience knowledge, attitudes or behavior.

One important purpose of message construction, for example, is enhancing efficacy beliefs to promote risk reduction behaviors. Fear appeals can result in target audiences denying risk rather than taking protective behaviors. One of the more important factors in improving the effectiveness of messages is that of source trust and credibility. Agencies are particularly vulnerable when warnings and forecasts are issued. If warnings are not issued and a risk event occurs, agencies can lose credibility because the public views them as not "on top" of the hazard. However, issuing a warning in cases when nothing happens tends to decrease credibility because the agency was obviously wrong. The next forecast is then less credible. Risk communication research studies how such messages can be constructed to better communicate the nature of a warning or a forecast so audiences more clearly understand probabilities and likelihoods of a negative event and respond in ways that reduce vulnerability and respond to impacts.

Another important areas of message development and design relates to the formatting and presentation of the message. These factors have been found to significantly influence an audience's understanding of information, their perceptions of the sending agency, their disposition to think about the relevance of the information, and their decision to seek additional, supporting or contradictory opinions or facts (Scherer et al. 1999). For agencies which routinely send risk-based messages, it may be critical to understand how such messages are received by the audience, audience trust, message believability, and behavioral intentions.

Studies that analyze the characteristics of a risk on a range of known important dimensions can help in developing accurate and understandable messages. Dimensions include whether the risk exposure is voluntary or involuntary, whether the hazard is natural or man-made, whether it is familiar or unfamiliar, dreaded on not dreaded, chronic of catastrophic, knowable or unknowable, whether the information comes from a trustworthy or an untrustworthy source, and whether the process is responsive to individual or community needs or unresponsive.

6. Development of Communication Strategies. How messages are communicated (e.g., media channels), the objectives of the communication, and the assumptions of change all contribute to the likely effectiveness of the communication effort. Development and implementation of communication strategies, in order to be effective, must be more than a creative activity. Communication strategies need to be based on sound social science research, audience analysis, theories of change, how audiences receive information, how social linkages influence beliefs and perceptions, the level of organizational trust, and the relevance of the information to the intended audience. Theories of change, or even assumptions of how groups, communities or individuals change as a result of information, determine the type of communication strategy developed. For example, if the assumption is that more information will result in risk-protective behaviors of a population at risk, one type of communication strategy will be developed. If the assumption is that change is most likely to result when messages building organization trust are used, a different type of strategy may be developed. Reducing the likelihood of ineffective communication and improving the quality of communication require both formative and evaluative research. Formative research can prevent major communication errors, and summative research can help provide guidelines for more effective and efficient future communication.

Research Methods

A broad range of research methods are appropriate for studying risk communication. These include traditional focus groups, interviews, and surveys, as well as fast-cycle surveys which compress the time needed for conducting the survey from months to weeks. Other techniques include the use of a mental models approach which constructs "mental maps" of how an agency and interested publics conceptualize a risk situation, and use that information to design communication strategies to meet the needs of both parties. Another method, co-orientation studies, compare perceptions between impacted parties to better understand how communication can be improved. All these methods can be applied to studies enhancing the effectiveness of communications about risks associated with HABs.

Example Project 1

Improving Fishery Closure Communication

Description: Risk perception studies prior to fishery closures can help determine the range of concerns, trust levels, and information needs of stakeholders – information that is critical for fishery managers and public health authorities to develop communication messages and strategies effective at promoting risk-wise public behaviors. For example, for those who insist that HAB events are not a real problem, research can reveal why they believe this and what information will increase their confidence in and compliance with closures. For those at the other extreme who are uncertain whether unaffected fisheries are safe, awareness of their perceptions and concerns can help agencies design messages that increase trust and promote understanding of the relevant science.

Methods: Focus groups and fast-cycle surveys can assess the range of concerns, perceptions, and needs of the various stakeholder audiences.

Outcomes: More effective messages and communication strategies that improve agency credibility, develop social network linkages supporting agency decisions, facilitate efficiency of communication with stakeholders, and ultimately promote public behaviors that prevent and respond to impacts of HABs.

Challenges: Because social situations may change rapidly (e.g., economic conditions in the community, risk events such as fishery-induced illness or death, or media coverage of an event), any social survey must be regarded as a "snapshot" of a community.

Expertise Needed:

- Risk Communication
- Statistician
- Field interviewers, including focus group facilitators

Timeline: Three months to one year.

Estimated Cost: Depending on geographic target area and study population, projects may range from $65,000 to $200,000.

Example Project 2

Effectiveness of Agency Messages Delivered to the Media and/or Public

Description: The purpose of this project is to assess the effectiveness of agency information releases to the media (or directly to the public in the form of web information, leaflets, etc.) at meeting agency objectives such as building trust and credibility, communicating important and relevant science, and addressing public concerns related to health, sociocultural, and economic interests. The study would examine agency communications and analyze their themes, follow how the media used the materials (e.g., modified or edited), and test the perceptions of a sample of intended stakeholders to determine efficacy of communications for agency objectives.

Methods: Content analysis of communication materials, analysis of media published stories, and an experimental design testing with a sample of appropriate stakeholders.

Outcomes: Improved understanding of how agency information is being understood and used by media and stakeholders to inform development of more effective communication messages and strategies.

Challenges: Because not all agency communication materials can be included in such a study, a major challenge will be to select an appropriate sample of materials which will represent the range of messages being sent to the media and the public.

Expertise Needed: Researchers experienced in content analysis and field researchers experienced in quasi-experimental field research.

Timeline: One to two years.

Estimated Cost: $90,000 to $240,000, depending on quantity and type of materials analyzed, geographic target area, and study population.

Example Project 3

Improving Agency Understanding of Target Audiences

Description: One of the difficulties of risk communication is that stakeholder and scientists/regulators generally have very different and often conflicting views of the nature of an environmental or health hazard. Research highlighting these differences can often dramatically improve communication for both stakeholders and the agency. Questions to be addressed include: What information does the target population currently have? How believable is it? Do they see the information as relevant? Do they trust agency communication? How well do they understand the goals of the agency? Do they perceive any risk (related to agency activities such as fisheries or beaches)? Specific problems may relate to topics such as: (a) Closure of fishing areas where there have been no health problems (because of successful closures), but local communities, visitors and other stakeholders believe that closures are unnecessary. (b) Effective delivery of forecasting information and warnings, recognizing that agency credibility can easily decline with the likelihood of false warnings or forecasts. (c) Situations in which stakeholders are unaware of hazards that have been identified, but community cooperation and participation is needed for monitoring and/or response.

Methods: Focus groups and fast-cycle surveys can assess the range of concerns, perceptions, and needs of the various stakeholder audiences. This research would also include scientists, regulators, and educators charged with communicating with and working with the community. The research could utilize a co-orientational approach or a mental models focus (described above).

Outcomes: Greatly improved understanding of the needs, perceptions and roles of stakeholders, regulators, scientists and educators. Sharing this information among all parties can result in greatly increased communication opportunities.

Challenges: Such studies involve intense periods of data collection, followed by a need for opportunities to involve the various involved parties in discussion.

Expertise:
- Risk communication
- Statistician
- Field interviewers

Timeline: One to two years

Estimated Cost: Depending on geographic target area and study population, projects may range from $100,000 to $200,000.

5. Coordinating Approaches to HAB Problems

HARRNESS highlights the importance of effective coordination among scientists, resource managers, public health and social service agencies, legislatures, affected communities, concerned citizens and other partners that play an integral role in reducing and responding to impacts from HABs in the US (e.g., HARRNESS, page 1). This section discusses the need for research in an area of social science called "Institutional Analysis" to optimize the effectiveness and economic efficiency of coordinated approaches.

Research Need: Analyze, and develop strategies to promote, the effectiveness and efficiency of coordinated governance, institutional, and socio-political processes in reducing and responding to the impacts of HABs.

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Institutional analysis (IA) refers broadly to research addressing the roles of governance, institutions, and processes (organizational, management, and political) in relation to HABs. Institutions and processes may either facilitate or hinder responses to HABs. For example, state human health and shellfish management programs may work well together or differences in regulatory standards or approaches across jurisdictional boundaries (e.g., federal and state) may hinder effective management.

The benefits of IA are well stated in a 2001 report of GESAMP (the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection, an international scientific consultative body organized to assist the UN, UNEP, FAO, and a number of other international environmental organizations), in a major assessment of needs for controlling land-based source pollution worldwide (GESAMP 2001):

> "IA provides a systematic way of obtaining an understanding of the nature, strengths and weaknesses of institutions within the context in which they are operating or which it is proposed they may operate in the future. It is therefore a key element in moving away from sectoral-based management of natural resources to a holistic approach that is likely to require modifications in the role of different institutions."

Following Elinor Ostrom (1990), institutions are viewed from a broad perspective understood to consist simply of groups of actors governed by agreed rules and norms. Institutions can be informal or informal, with formal organizations such as government agencies a special case. Similarly, governance is understood to be the larger system of actors and organizations engaged in a policy arena in which formal governmental arrangements are operating to address a particular problem or opportunity. Government is at the core of governance. The organizational, managerial, political and other processes affected by HABs outbreaks or engaged in proactive response to the threat of HABs are similarly broadly construed.

From the perspective of institutional analysis, HABs natural science research can be viewed as the product of a specialized set of scientific institutions and actors, and its role in the HABs arena can be examined just as the roles of other institutional or organizational entities can be (Leschine et al. 2003). An important role for institutions that incorporate scientific research is support for communications between researchers and users of research findings (managers and other interested and affected parties). Effective institutions facilitate potential users of research results helping frame the questions that researchers examine as well as researchers informing users of relevant results (Judd et al. 2005). This process of framing and informing was referred to as "analytic-deliberative" in an influential report of the National Research Council on the management of environmental risks (1996).

The connections that any actors or institutions have to the HABs problem can be either direct or indirect. For example, public health agencies may be directly engaged in determinations of whether beaches should be open or closed to shellfishing, while restaurants and motels far from shorelines, perhaps organized through local chambers of commerce whose primary purpose is to maximize local economic opportunity, may be indirectly affected by the decisions these institutions make. Even where the primary social problem in the face of a HABs outbreak may be seen to be one of individual behavioral choice – for example, the willingness of individuals to volunteer cooperation with closures or other mitigating measures – institutions may lie at the core of the problem, particularly if institutional barriers or lack of institutional trust hinder behavioral change.

Institutional studies can take a great variety of forms. One thread long-prominent in organizational and management studies is that of the "collective choice" problem. Simply put, a fundamental question is whether the conditions that prevail in a problem arena conducive to the emergence or sustenance of institutional arrangements can effectively manage "commons" problems over long periods of time (Ostrom 1990, Dietz et al. 2003). Ostrom's institutional analysis and development (IAD) framework directs researchers to focus on the key arenas in which actors engage over a particular problem, the strategies they undertake to keep transaction and other costs low in comparison to perceived benefits of interaction, the quality of the policy outcomes they achieve, and their institutional performance in crafting and putting into place policies and the institutional mechanisms that support them (Imperial 1999). At a more immediate level, researchers such as Eugene Bardach (1998) have developed understanding of conditions under which governmental interagency collaboration in a particular problem-solving arena can be expected to be effective.

The effectiveness of institutions at developing the capacity necessary to reach out to public and other stakeholders, engage in bargaining with other institutions, develop conflict resolution measures, and "create, collect and disseminate scientific knowledge" (Haas, Keohane, and Levy 1993) are additional potentially productive avenues for institutional analysis in relation to HABs. The role of scientific and technical information in environmental problem solving is another thread that has received attention in institutional studies, going back to pioneering work of Dorothy Nelkin on nuclear power, the supersonic transport airplane (SST), and other controversies of the 1960s and 1970s. The emphasis in such studies is often on whether the scientific information brought into a policy arena has sufficient impact to induce the organizational learning necessary for policy change to occur (Sabatier and Jenkins-Smith 1993), or whether shared beliefs about scientific and technical aspects of a problem are sufficiently strong and wide-spread to induce the emergence of a "culture of science" that contributes to problem identification and problem solving within a decision making organization (i.e., understood by Haas and colleagues (1993) as an "epistemic community").

Research Objectives

An overarching objective for IA in the context of HABs could be stated as determining how governance, institutions and socio-political processes help or hinder effective and efficient resource management in relation to HABs.

1. *Examine institutional arrangements to determine the degree to which approaches to HABs management are integrated or fragmented.* Fragmented management raises transaction costs on participants and may lead to ineffective or inefficient overall management.

2. *Examine collection and dissemination of HABs-relevant information by institutions for evidence of improved effectiveness and efficiency of management.* A "value of information" question that focuses on the role of institutions in fostering and utilizing information collection and dissemination. Effective use of information should result in more flexible and adaptive management.

3. *Examine the role of institutions in enhancing or eroding resilience in coupled human- natural-world systems affected by HABs.* Coupled human- nature- systems are resilient if both systems are able to adjust to "shocks" to either one. Does management succeed in limiting damage to recreation and tourism-dependent economies

while still maintaining protectiveness for human health?

4. *Examine the robustness of institutional arrangements from the perspective of IAD, asking whether incentives structures and other important institutional aspects to effective HABs management are robust, functioning and sustainable through time*.

Example Project

Leschine and his associate Meg Chadsey are using the IAD framework to examine interactions between researchers and managers in what has proved to be a successful effort to enhance the efficiency of Washington State's management of recreational shellfish harvests in relation to domoic acid contamination that has severely disrupted an economically, recreationally, and culturally important razor clam fishery (Leschine and Chadsey, in prep).

6. Education and Outreach

Research Need: Education and outreach products and programs that cultivate greater community awareness of HABs and a resurgence of stewardship of coastal ecosystems.

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Contributors: Dan Ayres and Lorraine Backer

HARRNESS aims to enhance national education and outreach to promote societal awareness of HABs that will "aid the medical community in diagnosis, will aid the seafood safety community in conveying the importance of closures," will promote adherence to warnings, and will contribute to collection of economic, public health, and sociocultural data on HAB impacts (such as the data needs identified in Section 1.1). These outcomes, in turn, will reduce vulnerability and promote effective mitigation of public health, sociocultural, and economic impacts of HABs. The bottom line is that "an informed populace is a prepared one" (HARRNESS 2005, 75).

> Achieving the goals of HARRNESS for the National HAB Educational Outreach Program requires sound scientific understanding and active participation of community audiences.

The success of education and outreach efforts for these outcomes relies on tailoring programs to deliver accessible information to, and harness the participation of, diverse sectors – including recurrently and potentially affected communities; the public health arena; and industries such as seafood, aquaculture, tourism, and recreational and commercial fishing. As HARRNESS affirms, "information should be developed in forms that are easily accessible and understandable and provided in formats that the community can use in meaningful ways." Toward this end, it is important to utilize social science methods such as focus groups to "listen closely to the needs of small coastal communities to provide quality information and resources to their schools, local organizations, and businesses" (HARRNESS 2005, 65).

Social science research is critical to characterize these diverse sectors in order to focus programs to actively involve them, effectively inform them, and ultimately facilitate beliefs and behaviors that reduce vulnerabilities and promote recovery from impacts. Sound scientific understanding of audiences, including characteristics such as the following, is critical to assess needs for educational and outreach programming.

- Demographics (e.g., age, ethnicity, and primary language of coastal residents and visitors);
- Knowledge (e.g., causes of HABs and symptoms of HAB illnesses);
- Attitudes (e.g., trust in resource management agencies);
- Beliefs (e.g., about the scientific predictability of HABs);
- Institutional characteristics (e.g., coordination across resource management, public health, tourism, and other sectors);
- Political setting (e.g., controversy over previous closures or reluctance of local businesses to communicate warnings);
- Information sources (e.g., primary use of television, radio, newspaper or other sources for information on closures or public health warnings); and
- Technological requirements (e.g., technologies accessible to and used by target audiences).

In addition to audience profiles describing characteristics such as these, evaluation of products and services is an essential contribution of social science research. Formative evaluation (i.e., assessment of effectiveness throughout an educational or outreach process) enables outreach program staff to adaptively improve or discontinue efforts based on lessons learned, changes in social or natural environment such as a shellfish bed closure, or changes in audience profile such as emerging distrust of resource management agencies. In contrast, summative evaluation provides information on the efficacy of a product or service for achieving established goals such as promoting active participation of coastal communities in volunteer phytoplankton monitoring networks, reassuring consumers of the quality of seafood products marketed in a local or regional area, or facilitating access to information about environmental impacts and health risks associated with HABs.

Achieving the goals of HARRNESS for the National HAB Educational Outreach Program requires sound scientific understanding and active participation of community audiences, as well as evaluation of program effectiveness (Fig. 12). The following discussion elaborates on these goals, focusing on the need to develop projects appropriate to specific audiences (Fig. 13).

Research Objectives

1. *Identify audiences integral to the goals established by HARRNESS for the National HAB Educational Outreach Program.* Assess audience characteristics to inform programmatic development and implementation. Facilitate the active participation of, and integrate the experience of, regulatory agencies, affected publics, and other groups. Outreach and education are critical to "maintain and disseminate information about HABs to ensure accurate knowledge, attitudes, and perceptions" – an outcome that is fundamental to facilitating public trust in regulatory agencies and risk-wise behavior (HARRNESS 2005, 65). Information must be provided to a wide variety of audiences that may be affected by HAB events or play an integral role in preventing and responding to impacts (Fig. 13). For example, walk-in medical clinics treat coastal visitors suffering from impaired breathing.

HARRNESS Goals for the National Educational and Outreach Program

- Develop and distribute easily accessible information about HABs environmental impacts and health risks.
- Develop communications focused on unusually susceptible populations such as different age groups, health status, and geographic distribution.
- Implement special language or culturally sensitive educational procedures for delivering health messages to underserved, culturally, or socio-economically isolated communities.
- Listen closely to the needs of small coastal communities to provide quality information and resources to their schools, local organizations, and businesses.
- Promote active participation of community and school groups in volunteer phytoplankton monitoring projects and ocean education stewardship programs.
- Provide multiple layers of communication on these subjects spanning local to global communities.
- Provide resources and monitoring programs to communities subsistent on local resources where other options may not be readily available.
- Work with industry representatives and regulatory agencies to enhance public awareness of health benefits that foster accurate perceptions of seafood/shellfish safety to reassure consumers of the quality of the seafood products being marketed.
- Work with medical schools and associations to improve physician education in the diagnosis, management, and reporting of HAB related illness.
- Work with teachers to better understand public school curricula at different grade levels to develop teaching sourcebooks and activities that promote understanding of algae, toxins, food webs, and health.

Figure 10. HARRNESS Goals for the National Educational Outreach Program (HARRNESS 2005, 65)

Education and outreach targeted at administrative and professional staff of these clinics should not only inform staff about HAB variability and predictions, but also explain the need for data collection and help to ensure their cooperation in the process. Although the primary goal is to educate audiences working on the "front lines" of the HAB-people gradient, education can also be beneficial for building new partnerships and facilitating the cooperation of public health workers and others in gathering research data.

2. *Identify, develop, and deliver decision support tools that are accessible to and used by decision makers and affected communities to prevent and respond to HAB impacts*. It is important to move research technology into general use as efficiently and effectively as possible. Tools need to be developed to assist scientists, health officials and local decision makers in conducting their work quickly and precisely. Matching their needs with the current technology development and commercial companies requires communication and investigation. Agencies such as the National Oceanic and Atmospheric Administration have developed partnerships such as ACT, the Alliance for Coastal Technologies, to assist in the identification and testing of sensors. Academic departments devoted to technology transfer assist University staff. Transferring tools for use by constituents requires understanding their knowledge, perceptions and skills as well as the institutional and political barriers they face.

3. *Identify and develop outreach and education programs and projects that facilitate stakeholder understanding and risk-wise response to HAB predictions, forecasts, and potential policy changes*. Although many sectors and segments of communities have a stake in the prediction and forecasts of HABs, they can be classified into audiences such as groups dependent upon seafood for subsistence; tourists; public health workers; industries such as seafood, aquaculture, tourism, and recreational and commercial fishing; local businesses; and civic leaders. It is important that each group receive appropriately-targeted and accurate information in order to facilitate behaviors (e.g., adherence to warnings) that reduce risks and promote recovery from impacts.

Example Audiences for HAB Education and Outreach

Bloom Ecology and Dynamics
Fishery Managers
Agricultural Sector
Educators and Students (K-Higher Education)
Taxonomy Graduate Students

Toxins and their Effects
Physicians
Medical Students
Public Health Officials
Emergency Medical Personnel
Wildlife Managers

Food Webs and Fisheries
Marine Mammal Stranding Networks
Fish Merchants
Aquaculturists
State Monitoring Programs

Public Health and Socioeconomic Impacts
Lifeguards
Subsistence Resource Users
Recreational Resource Users
Coastal Property Owners
Hotel Operators
Seafood Industry
Restaurant Industry
Charter Boat Operators
Tourists
Social Service Providers
Public Officials
Chambers of Commerce
Social Scientists
Land Use Planners and Managers
Media
Seafood Consumers
Water Utility Managers

Figure 11. Example Audiences for HAB Education and Outreach Initiatives

4. *Develop educational and outreach projects appropriate for interested public audiences*. Public audiences are diverse, including highly susceptible populations characterized by socioeconomic status, physiological traits such as pre-existing respiratory conditions, and cultural practices such as species harvested and food preparation techniques (see Section 2.4, *Identifying Susceptible Populations*). This diverse public, especially highly susceptible groups, must be aware of anthropogenic affects on HABs, and impacts to public health and communities, resulting from potential HAB blooms. To prevent and recover from impacts, it is important that the public be prepared for blooms and that additional projects be developed and made ready to implement during a bloom. The planning must include competent, flexible information to cover different bloom types and effects.

5. *Within the context of existing programs, identify and develop projects for K-12 education and teacher professional development*. K-12 audiences have specific academic requirements rooted in their state standard of study. These are often based on national standards or benchmarks, but are influenced on the local level. When designing programs for this group, it is important that curriculum writers become thoroughly familiar with a particular state's curriculum in biological or health sciences in order to design material that fits in and targets particular grades of interest. Ongoing K-12 volunteer monitoring programs such as NOAA's Southeast Phytoplankton Monitoring Network conduct work in some states and adapt programs as necessary to match the curriculum to the students, while retaining monitoring quality (http://www.chbr.noaa.gov/pmn/). Other programs such as the American Lung Association's Open Airways for Schools program target students at risk for asthma and therefore with risk of suffering effects of HABs (www.lungusa.org/site/pp.asp?c=dvLUK9O0E&b=44142). Fully developing these programs is as important as developing additional programs. Social science needs include information related to the local education process, the socioeconomic status of the area, and the specific needs of the students, e.g., whether their recreational and other activities put them at high risk of exposure.

Example Project 1

HAB Information and Needs Assessment Workshop for a Regional Public Health Community

Facilitating Objective 2 above, this project serves two purposes. The first is a goal of HARRNESS for education and outreach – distributing easily accessible information about HAB environmental impacts and health risks to relevant sectors such as the public health community (HARRNESS 2005, 65). To accomplish this goal, the project would convene a workshop for a regional public health community that includes an intensive educational component led by appropriate environmental, epidemiological, and social scientists. The second purpose is to assess information and tools needed by the regional public health community to diagnose HAB illnesses (see Section 2.1, *Developing Diagnostic Tools*), report HAB-related illnesses to improve surveillance (see Section 2.2, *Improving Surveillance*), and promote public education of HAB-related health risks. A variation on this approach could integrate information objectives and needs assessment across multiple sectors in a region, e.g., by involving key informants from tourism, seafood, recreational and commercial fishing, community and other groups. Workshops could be repeated and compared across regions.

Methods:

- Workshop facilitation
- Needs assessment
- Effective training techniques and technologies
- Group decision making and collaborative processes
- Workshop evaluation: Pre- and post-test to assess changes in knowledge and attitudes. Evaluation of workshop relevance to public health decisions. Track changes in effectiveness of diagnosis and monitoring of HAB-related illnesses, and communication strategies.

Outcomes:

- Assessment of information and tools needed by the regional public health community to diagnose HAB illnesses, report HAB-related illnesses to improve surveillance, and promote public education of HAB-related health risks. Multiple regional workshops could yield a comparison across regions with recurring, occasional, and rare HABs.
- Informed public health community

Challenges:
- Attendance and participation of regional health community.

Expertise Needed:
- Education component: HAB biophysical, social science, and epidemiological researchers. Education specialists.
- Workshop Facilitators

Timeline: A timeline for development and implementation of one regional workshop focusing on the public health community might be as follows:

1. Planning	4 months
2. Implementation	2 months
3. Evaluation	1 month
4. Assess information and tools needed, facilitate development by partners	4 months

Evaluation of workshop effectiveness would also be ongoing, informed by development and use of tools identified as needed by the public health community, dissemination of tools and lessons learned to other regions, and continued feedback of participants.

Estimated Cost: Approximately $150,00 to develop and implement two to three regional workshops. Cost depends on number of participants and number of regional workshops held, and the technologies used to complete them. The predominant expense is travel and associated needs of workshop participants.

Potential Partners:
- State and local health departments
- Hospitals and community health clinics
- Medical schools
- American Red Cross
- Lung health organizations
- NOAA Coastal Services Center (workshop planning, development and delivery of information, services and products identified by the public health community as needed).

Example Project 2

HABs Information for At-Risk K-12 Students and Teachers

Description: Facilitating Objective 5 above, the purpose of this project is to develop a lesson module on HABs targeted to at-risk students, particularly those with breathing impairments such as asthma, and promote its incorporation into an ongoing and effective K-12 education program such as the American Lung Association's Open Airways for Schools program. To inform development of the module and facilitate its use, the project would involve partnership with local community groups and schools in areas affected by HABs (http://www.lungusa.org/site/pp.asp?c=dvLUK9O0E&b=44142). The curriculum should include sourcebooks and activities that promote understanding of algae, toxins, and food webs as well as impacts of HABs on coastal environments, public health, sociocultural dimensions of communities, and local and regional economies.

Methods:
- Curriculum development – write and test a module on HABs
- Partnership development – e.g., American Lung Association's Open Airways for Schools program, community groups, and schools
- Train educators for delivery and evaluation.
- Collect and analyze evaluation data

Outcomes:
- K-12 citizenry and educators well-informed about the ecology and impacts of HABs
- American Lung Association (National and State organizations) informed of health risks associated with HABs, especially for individuals with asthma, and committed to related educational programming

Challenges:
- Developing partnership with American Lung Association

Expertise Needed:
- Demographic research capacity. For example, it will be necessary to identify locations with high numbers of K-12 students, particularly those with high rates of asthma (such as poverty areas)

or other attributes that make them particularly susceptible to health impacts, where there is a high or moderate risk of HABs.
- Education program and lesson plan development
- Training
- Evaluation, e.g., pre- and -post tests, follow-up evaluation at 1 year, oral questions of students.

Timeline: 2 years. Partnership development and curriculum development are predominant.

Estimated Costs:
- Demographic work, contracted at $12,000
- Educator, contracted at $50,000
- Travel for partnership development and training, $15,000
- Total $77,000
- Could be completed by Education graduate student, $45,000 stipend and travel per year

Potential Partners:
- American Lung Association and state organizations such as the American Lung Association of Florida
- Community foundations
- Local civic organizations such as rotary
- Environmental Protection Agency
- Centers for Disease Control and Prevention

Alternatively, a K-12 health curriculum for coastal communities could be developed that includes many coastal hazards such as microbiological contamination, hurricanes, and climate change. Such a curriculum should be compatible with state health standards, state and National Science Education Standards and Benchmarks for biology, single cell organisms and environmental science, habitat and pollution. Activities could be developed for each appropriate grade level and disseminated through professional teachers' meetings for health and science.

Recommendations

Recommendation 1. The Interagency Working Group on Harmful Algal Blooms, Hypoxia, and Human Health (IWG-4H) should consult with a sufficiently diverse cross-section of human dimensions researchers and utilize this research strategy as a basis for conducting local and regional scientific assessments, identifying innovative research and development needs, and developing programs as required by the Harmful Algal Bloom and Hypoxia Amendments Act of 2004 (HABHRCA).

1.1 The Prediction and Response Report developed by the IWG-4H should identify innovative human dimensions research and development needs for effective HAB prediction and response.

1.2 As part of the National Scientific Research, Development, Demonstration, and Technology Transfer Plan, in order to provide for human dimensions research and development needs identified in the Prediction and Response report, the IWG-4H should establish a multi-agency partnership to coordinate a competitive, peer-reviewed human dimensions research program modeled after ECOHAB.

1.3 Following NEPA, (a) Scientific Assessments of Freshwater and Coastal HABs and (b) Local and Regional Scientific Assessments of HABs and Hypoxia should integrate the natural and social sciences to evaluate potential methods for preventing and responding to impacts.

JSOST and SIMOR Commitment to Human Dimensions

The Joint Subcommittee on Ocean Science and Technology (JSOST) and Subcommittee on Integrated Management of Ocean Resources (SIMOR), subsidiary bodies of the Cabinet-level Committee on Ocean Policy, identify human dimensions research as a cross-cutting priority to support coastal and ocean resource management. For example, a public workshop sponsored by JSOST in April 2006 to provide the ocean science communities an opportunity to guide development of an Ocean Research Priorities Plan (ORPP) identified human dimensions research as a cross-cutting priority in its natural hazards theme (http://ocean.ceq.gov/about/docs/JSOST_nathaz.pdf). Also, a Federal/State Task Team (FSTT) of SIMOR established in September of 2005 to inform the ORRP stated that "the new focus of ocean research must be on the comprehensive study of marine and coastal ecosystems … This focus should include a significant investment in enhancing understanding of the 'human dimension' as a key component of and influence on these systems" (SIMOR FSST 2006).

HABHRCA Requirements

JSOST established the Interagency Working Group on HABs, Hypoxia and Human Health (IWG-4H) to provide assistance in implementing the Oceans and Human Health Act of 2004 (PL 108-447) and Harmful Algal Bloom and Hypoxia Amendments Act of 2004 (HABHRCA)(PL 108-456). HABHRCA requires a number of reports, assessments, and plans, including: (1) Prediction and Response Report for Harmful Algal Blooms; (2) National Scientific Research, Development, Demonstration, and Technology Transfer Plan on Reducing Impacts from Harmful Algal Blooms (RDDTT); (3) Scientific Assessment of Freshwater Algal Blooms; (4) Scientific Assessment of Harmful Algal Blooms; and (5) Scientific Assessment of Hypoxia. In addition, the Secretary of Commerce is to coordinate with the Interagency HABHRCA Task Force to provide Local and Regional Scientific Assessments of HABs and Hypoxia as requested by states, tribes, and local governments (PL 108-456, sec 104).

- The Prediction and Response Report is to: (1) "review techniques for prediction of the onset, course, and impacts of HABs … and provisions for their development;" and (2) "identify innovative research and development methods for the prevention, control, and mitigation of HABs and provisions for their development" (PL 108-456, sec 103).

- The RDDTT Plan is to "establish priorities and guidelines for a competitive, peer-reviewed, merit-based interagency research, development, demonstration, and technology transfer program on methods for the prevention, control, and mitigation of harmful algal blooms" (PL 108-456, sec 104).
- The Scientific Assessment of Freshwater Algal Blooms is to assess current knowledge about HABs in freshwater environments and include a research plan for coordinating Federal efforts to advance scientific understanding of freshwater HABs as part of the Ecology and Oceanography of HABs (ECOHAB) program (PL 108-456, sec 104).
- The Scientific Assessment of Harmful Algal Blooms is to examine the causes, ecological consequences, and economic costs of HABs and describe potential ecological and economic costs and benefits of prevention, control, and mitigation methods (PL 108-456, sec 104).
- The Scientific Assessment of Hypoxia is to examine the causes, ecological consequences, and economic costs of hypoxia in US coastal waters and the Great Lakes and describe the potential costs and benefits of prevention, control, and mitigation actions (PL 108-456, sec 104).

Recommendation 1.1. The Prediction and Response Report developed by the IWG-4H should identify innovative human dimensions research and development needs for effective HAB prediction and response.

The IWG-4H is developing the Prediction and Response report by reviewing the capabilities of federal, state, and local programs (tribal and non-tribal) in HAB prediction and response. Based on this review, the report will identify gaps in capacity, i.e. innovative research and development methods critical to protecting environmental systems, economies, and communities in anticipation of and response to HABs (Quay Dortch, ECOHAB program coordinator, personal communication). The research and development needs described in this human dimensions research strategy represent significant gaps in national HAB capacity. The IWG-4H should utilize this research strategy to identify innovative human dimensions research and development needs for effective HAB prediction and response. Needs include social scientific approaches for:

- Assessing Social Impacts (Section 1.2)
- Assessing Community Vulnerability (Section 1.4)
- Assessing Economic Benefits of Forecasts (Section 1.5)
- Developing Diagnostic Tools (Section 2.1)
- Improving Surveillance (Section 2.2)
- Developing Epidemiological Methods (Section 2.3)
- Identifying Susceptible Populations (Section 2.4)
- Improving Water Quality Monitoring and Response (Section 3)
- Communicating Risks to Prevent and Respond to Impacts (Section 4)
- Coordinating Approaches to Prevention and Mitigation (Section 5)

In addition to utilizing this strategy, the IWG-4H should consult with a sufficiently diverse cross-section of human dimensions researchers to implement the requirements of HABHRCA. Involvement of human dimensions researchers is critical both to provide information and to develop interdisciplinary collaborative partnerships for HAB research and response. Toward this end, it is not sufficient to consult with Epidemiologists and Economists at the exclusion of researchers with expertise in other critical areas, e.g., Risk Communication, Sociology and Anthropology, and Institutional Analysis.

Recommendation 1.2. As part of the National Scientific Research, Development, Demonstration, and Technology Transfer Plan, in order to provide for human dimensions research and development needs identified in the Prediction and Response report, the IWG-4H should establish a multi-agency partnership to coordinate a competitive, peer-reviewed human dimensions research program modeled after ECOHAB.

Development and implementation of workshops and other efforts informing the RDDTT plan should be substantially informed by this human dimensions research strategy and a sufficiently diverse cross-section of human dimensions researchers as early as possible. To provide for human dimensions research needs identified in the Prediction and Response report and facilitate interagency approaches to data collection and management, the IWG-4H should establish priorities and programmatic guidelines for substantial interagency investment in human dimensions research integral to the RDDTT plan.

Specifically, following the model of the Ecology and Oceanography of Harmful Algal Blooms (ECOHAB) program, the RDDTT plan should establish programmatic guidelines for a multi-agency partnership to coordinate a competitive, peer-reviewed research program providing for human dimensions needs established in this report and the Prediction and Response report. NOAA's National Centers for Coastal Ocean Science (NCCOS) is an appropriate lead for such a multi-agency HAB-Human Dimensions program (HAB-HD) in view of its experience as an integral partner in ECOHAB, leadership role in developing this report, and interest in multiple human dimensions areas essential to promote coastal environments and communities that are resilient to HABs and other extreme events (http://www.nccos.noaa.gov/). NCCOS should coordinate with other interested NOAA offices such as Sea Grant, Office of Education, and Coastal Services Center. Other agency partners may include, but should not be limited to, the Environmental Protection Agency (Drinking Water Impacts), Federal Drug Administration, Centers for Disease Control and Prevention (Public Health Impacts), US Fish and Wildlife Service, and the National Science Foundation Social, Behavioral and Economic Sciences area.

Recommendation 1.3. Following NEPA, (a) Scientific Assessments of Freshwater and Coastal HABs and (b) Local and Regional Scientific Assessments of HABs and Hypoxia should integrate the natural and social sciences to examine potential methods for preventing and responding to impacts.

The National Environmental Policy Act requires Federal agencies to utilize a systematic, interdisciplinary approach to decision making that integrates the natural and social sciences to study and evaluate alternative courses of action such as strategies for preventing and mitigating the sociocultural, health, economic, and environmental impacts of HABs and hypoxia. Following a NEPA-inspired model, (a) Scientific Assessments of Freshwater and Coastal HABs and (b) Local and Regional Scientific Assessments of HABs and Hypoxia should integrate the natural and social sciences to examine potential methods to prevent and respond to impacts. Toward this end, such assessments should be coordinated across HAB programs focused on natural science (such as ECOHAB) and human dimensions (such as the multi-agency human dimensions program proposed above).

Critical human dimensions information and methods for envisioning and evaluating strategies as part of such assessments include:

- Assessments of Social Impacts (Section 1.2)
- Assessments of Economic Impacts (Section 1.3)
- Assessments of Community Vulnerability (Section 1.4)
- Assessments of the Economic Benefits of Forecasts (Section 1.5)

Potential prevention and mitigation strategies examined by such assessments include:

- Diagnostic, Surveillance and other Decision Support Tools (Sections 2.1 and 2.2)
- Innovative Epidemiological Methods (Section 2.3)
- Identification of Susceptible Populations (Section 2.4)
- Water Quality Monitoring and Response Plans (Section 3)
- Messages and Strategies for Communicating Risks (Section 4)
- Models for Coordinating Prevention and Mitigation Strategies (Section 5)

Recommendation 2. The Interagency Oceans and Human Health (OHH) Research Program should establish goals and priorities for human dimensions research integral to its Interagency Implementation Plan. OHH research programs should draw on the research objectives and example projects in this report to develop requests for competitive research proposals.

The Oceans and Human Health (OHH) Act requires the interagency OHH Research Program to develop an Interagency Implementation Plan for Congress. Among other requirements, the plan is to establish ten-year goals and priorities to advance scientific understanding of the connections between oceans and human health; describe activities such as funding and training required to achieve them; and use reports and studies conducted by Federal agencies and other expert scientific bodies (PL 108-447).

This human dimensions research strategy is an important resource for the Interagency Implementation Plan. While the strategy focuses on HABs, it provides a framework for human dimensions research related to the connections between human health and a wide array of coastal hazards (including cumulative and episodic human impacts such as pollution and oil spills in addition to chronic and episodic natural events such as HABs and hurricanes). Accordingly, the Interagency Implementation Plan should utilize the research objectives and example projects in this report to establish ten-year goals and priorities, and estimate funding for competitive research. Areas of emphasis may include:

- Assessing community vulnerability(Section 1.4)
- Developing decision support tools (Section 2.1)
- Improving surveillance of human disease (Section 2.2)
- Developing epidemiological methods for identifying and characterizing human diseases (Section 2.3)
- Identifying susceptible populations based on environmental and sociocultural factors (Section 2.4)
- Improving water quality (Sections 3.1-3.3)
- Communicating risks of coastal hazards (Section 4)
- Coordinating mitigative approaches (Section 5)
- Improving education and outreach (Section 6)

In addition, OHH research programs should draw on the research objectives and example projects in these sections to develop requests for competitive research proposals.

> Recommendation 3. The National HAB Committee should integrate members in critical human dimensions research areas such as Risk Communication, Anthropology and Sociology, and Institutional Analysis in addition to Economics and Epidemiology.

HARRNESS established a rotating, interdisciplinary National HAB Committee to "represent priority research areas" and "facilitate coordination and communication of activities for the US HAB community at a national level." This committee should integrate members in critical human dimensions disciplines such as Risk Communication, Anthropology and Sociology, and Institutional Analysis (in addition to Economics and Epidemiology). Representation of priority human dimensions research areas is critical to facilitate comprehensive and effective implementation of HARRNESS; facilitate support by broad stakeholder groups; and "raise the visibility and understanding of HAB issues nationally" (HARRNESS 2005, 59).

> Recommendation 4. NOAA's Monitoring and Event Response for Harmful Algal Blooms (MERHAB) program should utilize this report to identify and implement mission-critical human dimensions research.

Initiated in 1999, NOAA's Monitoring and Event Response for Harmful Algal Blooms (MERHAB) program aims to incorporate tools, approaches and technologies from HAB research programs into existing HAB monitoring programs and provide managers with timely information needed to enhance and sustain routine HAB monitoring capabilities and mitigate HAB impacts (http://www.cop.noaa.gov/stressors/extremeevents/hab/current/fact-merhab.html). Toward this end, MERHAB is expanding the number of coastal regions benefiting from advancements in algal identification, detection, modeling, and prediction. For example, MERHAB "regional" projects are mitigating HAB impacts and enhancing HAB capabilities for *Karenia brevis* in the Eastern Gulf of Mexico, cyanobacteria in the lower Great Lakes, *Pseudo-nitzschia* along the central and southern California coast, and *Karlodinium micrum* in the Chesapeake Bay. In addition, MERHAB "targeted" projects are producing new technologies for faster, easier, and more economical methods of detecting a variety of HABs and their toxins. MERHAB is providing critical research and development investments needed by the HAB community to bring these promising methods into routine use to monitor coastal waters, test seafood quality, understand toxic effects on endangered marine species, and prevent human illnesses and deaths due to HAB toxins.

A critical factor in the successful transition to operations of MERHAB projects is the inclusion of state risk management agencies and state scientists in the design and implementation of research projects. Partnering academic and Federal scientists with scientists working in state agencies provides an opportunity to closely align research with the needs of agencies that are on the front lines of mitigating HAB impacts, generating research products that have immediate or near-term application. This approach echoes the emphasis in Section 2.1, *Developing Diagnostic Tools*, on understanding and collaborating with potential users of tools throughout the research, development, prototype testing, and deployment process. The injection of management needs into MERHAB science projects also allows for a better understanding of the regionally-specific political realities that must be addressed in order to obtain long-term funding for routine HAB monitoring and response efforts.

MERHAB researchers have identified a number of critical needs that could be addressed by the social science research community. These include:

- *Region-specific data on the sociocultural and economic impacts of HABs* (Sections 1.1-1.3). Local fishery managers can generally discuss why the public participates in the fisheries they manage and why their fishing activity is important to their quality of life. However, without the help of social scientific approaches, it is difficult for fishery managers to comprehensively document and quantify the sociocultural and economic losses when HAB events preclude normal harvest opportunities and other resource uses. Surveying local communities about the social importance of resources and how they adapt to resource impacts will help managers develop effective response strategies and tailor outreach products. It is important to document impacts so that appropriate prevention and mitigation strategies can be funded, planned, and implemented. This kind of information will also assist members of the HAB community in telling the "whole" story of HAB impacts as they approach federal, state and local lawmakers to request funding for HAB related work. There are many people who are not affected economically by a HAB event, yet who find their social quality of life deeply affected.

- *Improved messages and strategies for communicating to public audiences about risks associated with HABs to reduce vulnerabilities, respond to impacts, and raise public awareness of the importance of routine monitoring and response* (Section 4). Often, the public learns of HABs at the time of a fishery closure. This can lead to frustration, anger, distrust of government actions and, ultimately, health impacts due to failure to comply with governmental warnings. State managers who struggle with HAB-related impacts should consider consulting with risk communication researchers to help them effectively reach populations that are affected by HAB events and/or integral to HAB monitoring and management.

Longer-term needs may include:

- *Utilization of social information to plan and implement short-term rapid response efforts*. Such information could include an understanding of community vulnerabilities to impacts (Section 1.4), identification of susceptible populations (Section 2.4), or models for agency and stakeholder coordination (Section 5).

- *Risk communication research to effectively utilize HAB prediction and forecasting information in communicating risks to various publics* (Section 4).

Recommendation 5. State and local resource managers and other leaders should coordinate regional partnerships integrating the public health community, biophysical and social scientists, affected tribal and non-tribal communities, and other partners to address regional HAB issues.

An example of such a partnership is the widely discussed success story of Washington State's ORHAB (Olympic Region Harmful Algal Bloom) Project (http://www.orhab.org/). This collaboration of HAB researchers, fisheries managers and human health managers has successfully met the challenge of bringing scientists and managers to a common set of goals and coordinated approaches to achieving them. The partnership has improved understanding of the state's coastal HAB issues and contributed to the development of solutions. Natural barriers (e.g., collaborating across cultural, disciplinary, and agency boundaries) between these diverse groups were lowered during the process. Managers increasingly understand and use the "language of science" and researchers increasingly appreciate the challenges faced by managers, framing their research questions to inform on-the-ground decisions. State and local leaders should form such regional collaborations in other parts of the nation as a means of producing effective and locally appropriate solutions to local HAB issues.

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