Background Description and Learning Experience

In 2010, North Carolina has participated in the Association of State and Territorial Health Officials (ASTHO) Tracking Fellowship Program. This fellowship funds a state staff member to learn about tracking at a national workshop and visit a site to gain a better understanding about EPHT. As a fellowship project, "Climate Indicators for HAB Events is in progress and should be completed in August 2010. This project focuses on the predictive nature of climate indicators for cyanobacterial (a.k.a blue-green algae) blooms in North Carolina. Predicting the likelihood of an algal bloom that produces toxin will greatly aid entities such as public water supplies that use fresh surface source waters, recreational sites such as lakes, and the general public in order to protect potentially exposed groups from the impacts of HABs. This protection will be particularly important for the most vulnerable populations, including children, the immune compromised, and the elderly. Household pets that are exposed by drinking contaminated water will also benefit from being protected.

National Environmental Public Health Tracking Conference – April 2010

Lessons Learned:

The first lesson learned from the National EPHT workshop was just how complex the information systems are to incorporate into an EPHT network. There are many diverse datasets that must be considered. Each one has its own privacy and data steward pitfalls. In North Carolina, we have focused primarily on the required indicators. We will need to discuss this issue at length in the fall.

The second lesson learned was the importance of key contacts about EPHT through social networking. An important aspect of any new program is to develop good contacts for future collaborations and information. This was especially true during the content working group sessions. The areas where contacts were made included other fellows, pesticide working group, and the climate change working group. These new and developing relationships can only strengthen North Carolina's EPHT efforts.

The third lesson learned was that participation in the content working groups helped to determine the relevance of North Carolina current EPHT indicator activities. Detailed information regarding datasets and indicators was very useful in these sessions. These working groups helped to define the scope and complexity needed to implement these indicators.

Host State Site–Visit – May 2010

Lessons Learned:

The first important lesson learned was the importance of data acquisition from the data trading partners. An issue that was raised is who has access to the data. Maryland has a tiered system where tracking information is designed to meet the specific needs of the users (community, local health departments, state agencies, and academia). For example, a researcher can use part of the system that can address inquiries without revealing confidential information. This tiered system of data access lends itself to the confidence of the data trading partners that other agencies are not hijacking their data and they have control. Using a tiered system for data use is an important bargaining tool for creating memoranda of agreements with the data trading partners.

The second lesson learned was that information technology comprises a lion's share of the infrastructure. A tour of the equipment needed to store, compile, and process data demonstrated just how large a mature EPHT program must maintain -no small feat! The information technologist walked through the different aspects of the system including firewalls necessary for confidential information and access control. Mapping using Geographic information systems was also demonstrated.

The third lesson learned was just how complex the portal to the community needs to be in order to convey the information visually. The Maryland EPHT program partners with UMD for the software development of the data portal. The data portal is the place where visual inquiries can be made based upon the level of access to the overall system. This portal speaks with the information technology infrastructure at the state. Inquiries can be made and are visually represented on maps. These inquiries and the maps generated can be used by local health departments, state agencies, and the community to learn about about environmental hazards and the subsequent health effects associated with those hazards and associated trends. Community health education materials, risk assessments, and health promotional activities (e.g. safe and health choices) can be developed.

A current *effort* of the Maryland EPHT program was to catalog metadata. Describing data about data is tedious, but necessary for epidemiology and tracking to insure compatibility with the national system and to discover data "holes" that are needed to be plugged. The fourth lesson learned is to prepare metadata as we recruit data trading partners in a standardized format.

NC *EpiNote* Article about Environmental Public Health Tracking

Discussion:

The North Carolina State Epidemiologist/Epidemiology Section Chief along with the Head of the Occupational and Environmental Epidemiology (OEE) Branch, wanted an article about EPHT for an upcoming NC *EpiNote* newsletter. This news letter reaches all local health departments across the state. It can also be access on-line. The purposes of the article were to explain what EPHT is and our current tracking efforts.
Lessons Learned:

Summarizing EPHT helped to provide a foundation to explain the basics of EPHT in a professional and concise way that is understandable by epidemiologists at state and local health departments. It also shows the trend and direction of the section and branch with regards to EPHT in North Carolina. See Appendix 2 for a copy of the draft article.

Planned Activities

1. **North Carolina EPHT Ad Hoc Working Group**

   In preparation for the next CDC EPHT referral for applications (RFA) , we plan to convene an ad hoc working group to focus on plans to develop likely information technology infrastructure needs, identify key data trading partners, and create a memorandum of agreement template. A meeting is planned for fall of 201 O. For identified data trading partners, a meeting with each one explaining EPHT scope and ASTHO information about data providers will be initiated this winter 2010/spring 2011.

2. **Occupational and Environmental Epidemiology (OEE)**

   In preparation for the next CDC EPHT RFA, a logic model and program evaluation plan will be developed.

3. **North Carolina Private Well Water Initiative (OEE)**

   As part of an on-going independent EPHT effort in North Carolina for safe private wells, our focused activities include obtaining State Laboratory of Public Health well sampling data, geocoding the database, and compiling and transferring the data for storage at the State Center for Health Statistics (SCHS). Through funding from the National Center of Environmental Health Science (NIEHS) and the CDC Private Well initiative, North Carolina has embarked on the populating SCHS information technology infrastructure with a private well water database for the state. This database will be used to create hazard maps for communities and local health departments. These maps can also be used to help identify hazard trends, create risk assessments, and tailor educational materials to prevent or reduce exposure to these hazards in private well waters.

   The initiative is collaborating with the North Carolina Department of Environment and Natural Resources and the University of North Carolina at Chapel Hill School of Public Health to develop private well health educational materials. Other stakeholders will be recruited including representatives from the SLPH, Division of Environmental Well Program and the Public Water Section, and the Cooperative Extension from North Carolina State University. The University of North Carolina will develop the materials. The stakeholders will review them. The completed materials (and maps as stated above) will be posted on the OEE website. Some of the subject areas include when to test a private well, information about contaminants, and appropriate interventions (e.g. whole house or tap filters or reverse osmosis equipment). The goal of this effort is to provide individuals and communities with a "one-stop shop" of private well information.

Conclusions

1. The ASTHO EPHTO Fellowship program provided a detailed introduction to and practical experience of the magnitude and scope of developing and implementing a state EPHT program;

2. The ASTHO EPHTO Fellowship program provided an identification of common pitfalls encountered by new programs and ways to avoid them;

3. The ASTHO EPHTO Fellowship program provided a valuable social networking structure for future collaborations and information sharing;

4. The ASTHO EPHTO Fellowship program provided a means to identify strengths and weaknesses of a non-grant state through the use of a host site visit; and

5. The ASTHO EPHTO Fellowship program provided an opportunity to explore a pilot project subject area for practical application of EPHT (e.g. indicator development).

The focus for the NC EPHT Ad Hoc Working Group has been with the required indicators. After completing this fellowship, a shift to infrastructure planning and development, recruiting data partners, and developing memoranda of agreements will be our new focus. I came away with a much better understanding of what EPHT is and how it works at the state after completing this fellowship. I will use my site visit experience to help us plan a better vision and scope to develop and implement EPHT in North Carolina. This experience has been invaluable. I heartily recommend this program for any state wishing to pursue EPHT. I found the site visit to the host state the most illuminating.

Pilot Project

A Description of Human Complaint-Associated Harmful Algal Bloom Events and
Corresponding Drought Indicators for North Carolina, 2005 – 2009
(Truncated Version)

Abstract

Human complaints and concerns about algal blooms may serve as sentinel surveillance for toxin-containing blooms occurring during periods of drought. Conversely, indicators of drought may signal the likelihood of a harmful algal bloom. These complaint associated algal blooms are referred to as an event. To test these events and how they relate to drought, data about each event were collected including spatial, temporal, climate, drought (Palmer and Monitoring Indices), algal identification, and toxin analyses. Forty-seven distinct, non-repeating events were registered with the North Carolina Department of Health and Human Services (NC DHHS) from 2005 to 2009. These events occurred most frequently during periods of drought: low precipitation, high temperatures, and low Palmer Z index. Moreover, events occurring during a drought were more likely to contain an algal toxin when the Highest Drought Monitoring Index was used. Collective use of these indicators of drought may be able to determine when to craft public health messages to help people reduce or prevent exposure to possible harmful algal blooms in North Carolina.

Introduction

Drought is a condition of abnormally low precipitation that may affect both the quantity of surface water and ground water recharge (1). In 2007, North Carolina, along with other states in the southeastern United States, suffered one of the most severe droughts in decades (Figure 1 and 2). During this drought, the number of concerns and complaints about algal blooms and their possible adverse health outcomes were more frequently reported during that time compared to previous years. In North Carolina, hot and dry conditions along with low and variable winds allow sun light to penetrate the water column (upper region of a water body) whereby algae can proliferate. Moreover, yearly seasonal dry spells have been observed with a corresponding rise in the number of blooms (2), and subsequent health complaints, especially in the late summer through the early fall. There appears to be a relationship between drought and dry seasons with the number of concerns and complaints about algal blooms in North Carolina. Therefore, the purposes of this project are:

- Document and describe a historical baseline of complaint-associated algal bloom events in North Carolina; and
- Explore indicators of drought to help determine when to craft public health messages to the public state and local agencies about the likelihood of the conditions whereby a possible algal bloom may occur.

Methods

<u>Event Definition</u>

An event is defined as an algal bloom in ambient or drinking waters that is associated with human health concern or complaint in North Carolina that is reported to the Department of Health and Human Services (NC DHHS) by state or local public health officials, Department of Environment and Natural Resources (NC DENR) biologists, public water supply operators, or private individuals. Events about animal deaths (e.g. domestic animals including pets) and fish kills due to an algal bloom are also included. All water types (fresh, estuarine, and ocean) are incorporated.

Temporal, Spatial, Climate, and Drought Data

The investigation date and county of each event was recorded. River basin designation was obtained from a NC DENR, Division of Water Quality basin map (3). The corresponding eight-digit hydrologic unit code (HUC) numbers were obtained from the United State Army Corps of Engineers (4). A HUC is a drainage basin or a watershed. Ecoregion (Level III) designations were acquired using the United States Environmental Protection Agency (USEPA) Western Ecology Division map for North Carolina (piedmont, middle Atlantic coastal plain, southeastern plains, and Blue Ridge) (5). Ecoregions are defined as areas of similar ecosystems (6).

Drought monitoring index data (weekly whole state, highest level and area-weighted average) were obtained from NC DENR, Division of Water Resources, Drought Monitoring History (7). Categories of the drought monitoring index include normal, abnormally dry, moderate drought, severe drought, extreme drought and exceptional drought (Table 1). The highest level drought monitoring index is the highest category in a county regardless of the amount of area it represents. The area-weighted average drought monitoring index is the category that represents the greatest percentage of land in a county. State-level drought monitoring indices are determined by using the same methodology.

The state monthly precipitation, temperature, Palmer Drought Severity Index, Palmer Hydrological Drought Index, Palmer Z Index, and Modified Palmer Drought Severity Index data were obtained from the State Climate Office of North Carolina (SCONC) Climate Division (Table 2). Climate region designations (southern mountains, northern mountains, northern piedmont, central piedmont, southern piedmont, southern coastal plain, and northern coastal plain) were also obtained from the SCONC (8).

Toxin Data

Microcystin analyses of bloom waters were completed for each available event. Unpreserved bloom water (0.5 to 1 liter in amber glass bottles, refrigerated or transported with ice packs) was analyzed for microcystins using the QuantiPlate kit for microcystins high sensitivity enzyme-linked immunosorbant assay (ELISA) method (Envirologix, Portland, Maine) by the North Carolina State Laboratory of Public Health. Both extracellular and intracellular microcystins were analyzed using the extraction method by Metcalf and Codd (9). Limit of detection for the high sensitivity protocol was 0.03 parts per billion (ppb or micrograms per liter). The limit of quantification was 0.06 ppb (10). Freshwater and estuary blooms due to cyanobacteria that involved animal deaths or possessed a high degree of public concern were further evaluated for the presence and concentration of saxitoxin, anatoxin-a, and/or cylindrospermopsin by a commercial laboratory (GreenWater Laboratory, Florida). The marine toxin domoic acid was analyzed by the National Center for Environmental Health and Biomolecular Research, National Oceanographic and Atmospheric Administration (NOAA) located in Charleston, South Carolina.

Algal Genera Data

Identification of the most abundant algal genus or family (cells per ml or units per ml) was performed by NC DENR biologists or public water supply laboratory technicians/consultants.

Data Analysis

Descriptive statistics included the frequency, mean, median, standard deviation, and range for each variable using SPSS. Tables, bar graphs, box plots, and line graphs were created using SPSS, Microsoft Excel or Apple Numbers.

Results

Temporal and Spatial

A total of 47 distinct (non-repeating) events were identified during the five-year period from 2005 to 2009 (Figure 3). The largest number of events were recorded in 2007 (n = 17) and the smallest number of events in 2008 (n =4). The mean number of annual events was 9.4, the median was 9, and standard deviation was 4. 8.

All of the events occurred between the months of March through October (Figure 4). Approximately one-third of the events occurred during the month of August. No events were recorded for November through February. Eighty-five percent of the events were of freshwater origin with 93% of those events were from ambient water use such as recreational.

Over fifty percent of the events were located in either the Cape Fear or Catawba River basins (Figure 5). The most frequent HUCs were 3030002 (Haw, n = 6) and 3050101 (Upper Catawba, n = 6). Most events occurred in the piedmont ecoregion and the northern piedmont climate region. The events occurred across twenty-seven counties of North Carolina (map in progress).

Drought Indicators

The most frequent category of the highest drought monitoring index (HDMI) for events was moderate drought (Figure 6). The most frequent category of the area-weighted drought monitoring index (AWADMI) for events was normal (Figure 7). The mean, median, standard deviation, and range of the monthly total precipitation and monthly average temperature for the state, and Palmer Drought Monitoring Indices (PDMI) are shown in Table 3. Box plots of precipitation, temperature, and PDMI are depicted in Figures 8 -13.

Algae and Toxins

Identifications were available for nearly 70% (33/47) of the events. Cyanobacteria accounted for approximately 80% (26/33) of the events and generally occurred at or before August (Figure 14). The most commonly encountered genera of algae were *Microcystis* and *Aphanizomenon* (Table 4). *Aphanizomenon-identified* events occurred primarily in spring to summer whereas *Microcystis-identified* events occurred in summer to fall seasons (Figure 15). Algae associated with estuarine or ocean waters occurred most often during the months of August through October. *Pseudonitzschia pungens* was identified in September 2007. An off shore bloom of *Trichodesmium* occurred along the southern half of the North Carolina coast for several weeks from September to October 2007. *Karenia brevis* was also identified off shore in October 2007 at counts below the regulatory limit.

Eighty-one percent (38/47) of the events were tested for at least one algal toxin. Microcystins were tested in 36 of the events. Three events were tested for multiple toxins. A toxin was present in 58% (22/38) of the events tested. Two events had both microcystin and saxitoxin present. Anatoxin-a alone was present in one event as well as one event for domoic acid. Microcystin was present in 20 events (Figure 16) with a mean, median, maximum, minimum, and standard deviation concentration of 4.9, 0.5, 72.9,0.07, and 16.2 ppb respectively.

In August 2005, a public water supply detected a microcystin level of 1.02 ppb and 0.067 ppb of saxitoxin in finished (treated) drinking water to NC DHHS in October of that year. No adverse human health effects were reported.

In September, 2007, 62 nanograms per liter or parts per trillion (ppt) of domoic acid was detected in mussels and 11.8 ppt was detected in sea water. No reports of adverse human health effects were reported. Domoic acid concentration in shellfish was well below the regulatory limit of 20 ppb (20,000 ppt).

Adverse Human Health Effects and Animal Deaths

No adverse human health effects associated with the events were recorded during 2005 -2009. However, two occurrences of dog deaths were reported in 2009 that may have been due to exposure to algal toxins.

Events and Drought Indicators

It was observed that when the precipitation increased, the number of events deceased (Figure 17). Conversely, as the precipitation decreased, the number of events increased. This was also observed with the Palmer Z index (Figure 18). This general trend was not seen with the other drought indicators.

Toxins and Drought Indicators

The highest number of events with a toxin present was observed during 2007 (Figure 19). Most events were classified in the drought category compared to those classified into the normal or abnormally dry categories using the HDMI as an indicator for drought (Figure 20). Moreover, more events containing a toxin were classified into the drought category using the HDMI. These observations were not observed using the AWADMI.