Bioaccumulation Oversight Group Scoping Paper
Freshwater Bio-toxin Monitoring Workshop

Karen Worcester and Karen Taberski, January 1, 2012

Background

The majority of freshwater harmful algal blooms (HABs) reported in the United States and worldwide are due to one group of algae, cyanobacteria (leading to cyanobacteria HABs or CyanoHABs), although other groups of algae can be harmful. Cyanobacteria (also known as blue-green algae) are photosynthetic bacteria that are found naturally in fresh water systems throughout California. Under certain conditions cyanoHABs can occur, particularly in systems over-enriched by nutrients with elevated temperature, sufficient light intensity, and decreased water flow. CyanoHABs are not a recent phenomenon, but the frequency and geographic distribution seem to have dramatically increased in the United States and around the world. The issue of freshwater HABs has received more attention outside of the United States in the past, but now, as most U.S. states experience freshwater HABs, the issue is of growing national concern. The Harmful Algal Bloom and Hypoxia Amendments Act (HABHRCA) was signed into law in 2004. The HABHRCA acknowledges that HABs are one of the most scientifically complex and economically damaging issues challenging our ability to safeguard the health of our Nation’s aquatic and marine ecosystems. One of the main priorities outlined in the first report of the federal Interagency Working Group on Harmful Algal Blooms, Hypoxia, and Human Health is to “Improve knowledge of bloom occurrence through better monitoring” (Lopez, et al., 2008). They state that an ideal monitoring system would allow for real-time, highly automated, accurate bloom detection, that in the short run, could provide early warning of impending toxic events. In the long run, better predictive ability needs to be developed based on the results of increased monitoring, research and modeling.

Over forty cyanobacteria species can produce toxins as secondary metabolites – common toxin producers in California include *Microcystis*, *Anabaena*, *Aphanizomenon*, *Lyngbya*, *Gloeotrichia* and others. There are several cyanobacteria toxins, with the most commonly detected ones in California being microcystin and anatoxin-a. Individual species may produce one or more toxins, and individual toxins may have a number of different congeners. Blooms may be more or less toxic, depending on environmental variables. Toxins are typically released into the water column upon cell death or lysis, which can create a period of time when risk of exposure peaks, before the bloom collapses and the toxins dilute and/or degrade (SWRCB, CDPH, and OEHHA, 2010).

Exposure to cyanobacteria toxins can cause symptoms that range widely and include rashes, allergic reaction, blistering of the mouth, headache, gastrointestinal distress, vomiting, pneumonia, diarrhea, liver damage, and even death. Exposure to cyanotoxins has also been related to risk for amyotrophic lateral sclerosis (ALS or Lou Gehrig’s Disease), as well as other neurological diseases (Banack, et al., 2010). Over a dozen dog deaths have been attributed to cyanobacteria toxicity in California in the last decade (SWRCB, CDPH, and OEHHA, 2010). There is widespread documentation of livestock poisoning due to drinking water contamination from algal toxins (Duy et al, 2000). Recently twenty-one sea otter deaths were confirmed from microcystin intoxication, with evidence of an upstream source, transferred to coastal waters and through invertebrate food items as the most likely route of exposure (Miller, et al., 2010).

CyanoHABs have been causing problems in a number of waterbodies in California, and have resulted in drinking water supply concerns, wildlife and domestic animal deaths, and human health risks. They have been the focus of much concern in the Klamath River system. They have also been found in the Sacramento/San Joaquin watershed and Delta, and in a number of lakes including Crowley Lake, Clear Lake, Lake Isabella, Big Bear Lake, Lake Elsinore, Pinto Lake, as well as others.

Though microcystin-producing cyanobacteria are not typically considered a marine concern along the California coast, blooms have been documented in the Salton Sea, an inland salt lake (Carmichael and Li, 2006). Recent monitoring along the coast using semi-permeable membrane devices has detected microcystin in nearshore areas following periods of high river flow, as well as in river mouths entering the ocean (Miller et al., 2010). In addition, in fall of 2011, during the first monitoring run that measured algal toxins in San Francisco Bay, microcystin toxins were found from South San Francisco Bay up to the Delta. These toxins are presumed to be from an upstream, freshwater bloom.

In 2010, the California Department of Public Health, the Office of Environmental Health Hazard Assessment and the State Water Resources Control Board, working with the Statewide Blue-green Algae Working Group, released a draft “Voluntary Guidance” on harmful algal blooms, related to monitoring and public notification. The intent of this document is to: 1) provide background information on the problem, resources, and references, 2) describe environmental sampling approaches and 3) provide guidance on public notification, posting, and warning advisories to advise the public. Much of the general information in this proposal is summarized from the Voluntary Guidance.

California’s Voluntary Guidance includes an appendix on monitoring for cyanotoxins. It recommends monitoring that focuses first on human health concerns and secondarily on wildlife and livestock. It suggests when funding is limited to focus on areas where swimming or other human exposure is more likely. The monitoring approaches in the Voluntary Guidance are focused on assessing the nature and toxicity of a bloom and its risk to humans and other animals for the purpose of advising the public. It recommends characterizing nutrient ratios between nitrogen and phosphorus, with ratios under 10:1 being potentially more conducive to cyanobacteria blooms. It describes sampling for species identification as well as for chemical analysis of toxins in water. No EPA approved methods are currently available for the toxin analysis, but there are both LC-MS and ELISA methods. The Guidance includes a list of labs that can do the analyses (including the CDFG Water Pollution Studies Laboratory).

Dr. Raphe Kudela and associated researchers at U.C. Santa Cruz have developed Solid-Phase Adsorption Toxin Tracking devices known as “SPATT”. This monitoring technique involves the passive adsorption of biotoxins onto porous synthetic resin filled sachets (SPATT bags). The SPATT adsorb toxins from the dissolved phase, after cells release toxins to the water column. This approach has been used in the Central Coast in river mouths and in the nearshore marine environment. These devices do not provide a directly translatable measure of concentration in the environment. However, because they concentrate toxins at approximately ten-fold that of the ambient concentration (Kudela, pers. comm.), they provide a more sensitive, time-integrating approach to monitoring for presence of the toxins.

The World Health Organization has identified a Tolerable Daily Intake and guideline values of microcystin toxin in water based on different types of beneficial uses (drinking water, recreational exposure). There are no comparable values for exposure to anatoxin-a. The primary route of exposure is through ingestion, though aspiration and inhalation are also possible. These toxins primarily accumulate in the liver and viscera of fish, but have been detected in fillets. Similarly, toxins are most prevalent in shellfish viscera, but also accumulate in muscle. Miller et al. (2010) utilized tank experiments to confirm that mussels and other bivalves could concentrate microcystin in their tissues (up to 107 time ambient water levels), and required three weeks or more to depurate the toxin. Kanz (2008) reported on microcystin accumulation in both fish and freshwater mussels in the Klamath River system. Results from the Kanz study were used to support a consumption advisory on effected reaches of the Klamath River.

Biotoxin Monitoring Workshop

We are proposing that the Bioaccumulation Oversight Group fund a two-day workshop to develop a pilot screening study for algal biotoxins in fresh water systems in California. We are proposing that we concentrate our efforts on freshwater HABs because: 1) although poorly funded, the DPH manages a marine HABs program to protect the public from consuming shellfish with algal toxins, 2) there is no similar program for freshwater HABs and 3) many of the problems we are seeing in estuarine or nearshore areas are due to toxins from freshwater HABs being carried downstream. The workshop will include an overview of the species involved, the toxins and their effects, where they have been found and under what conditions, the tools and monitoring methods available, and the thresholds of concern. We also would like the workshop to highlight other fresh water biotoxin monitoring programs elsewhere in the country and world. During the second day of the workshop participants will discuss conceptual ideas for a pilot monitoring program to screen for biotoxins in California. An optional third half-day could include a field trip to a location where cyanobacteria blooms have resulted in monitoring and management measures.

Cost of the workshop will not exceed $25,000, with primary expenses associated with per diem and travel expenses for speakers not covered under their own employer’s budgets. Other costs may be incurred for printing, mailing, facility rental charges, field trip supplies, etc. Details are not yet available because costs associated with speakers and facilities are as yet unknown.

Proposed Schedule:

Day 1: Speakers provide information on the state of knowledge of freshwater cyanoHABs and associated monitoring.

- Background and status of cyanoHABs in California, the nation and world.
- Pathways/BU impacts (swimming, drinking water, consumption of fish and shellfish)
- Effects on humans, wildlife, domestic animals and fish
- Monitoring approaches/programs from other states/countries in water, tissue and sediment
- Novel monitoring approaches – SPATT, satellite imagery in combination with ground-truthing, in-situ sensors, other
- Status of laboratory methods
- Guideline values

Day 2: Workshop participants develop concept proposal for screening study through SWAMP/BOG

- Agree on need for statewide monitoring approach
- Establish goals, objectives of study; formulate management questions to be answered
- Agree on potential indicators
- Propose monitoring approach
- Define sampling framework (lakes, streams, marine interface?)
- Identify partners (NOAA, EPA, DPH, local health departments, universities, others)

Day 3 (optional half day). Arrange field trip to Pinto Lake with Robert Ketley (City of Watsonville) and Raphe Kudela (USCS) so they can describe their work on monitoring, posting, and managing the lake.

Potential Speakers:

Kim Ward, SWRCB - Status of cyanotoxin blooms and associated monitoring in California

Dr. Raphe Kudela, U.C. Santa Cruz – Use of SPATT as a monitoring technique in marine and freshwater environments

Dr. Melissa Miller, CDFG Center for Wildlife Health and Veterinary Medicine – effects of freshwater toxins on wildlife, birds and marine mammals

R.J. Kanz , SWRCB – Monitoring for biotoxins in the Klamath system – lessons learned

Alex Parker (RTC) – environmental parameters that cause/encourage blooms.

Dave Crane, CDFG Pollution Studies Laboratory – status of laboratory methods

Gail Louis, U.S. EPA Region 9 and member of federal Interagency Working Group

Lorraine Backer, Center for Disease Control, coordinator of federal Interagency Working Group

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