Regional Water Quality Control Board
North Coast Region

Executive Officer's Summary Report
Thursday, April 7, 2022
Regional Water Board Office
Santa Rosa, California

ITEM: 4

SUBJECT: Overview of the recently released report "Benthic Cyanobacteria and Cyanotoxin Monitoring in Northern California Rivers, 2016-2019" detailing the monitoring work and findings of the North Coast Regional Cyanobacteria Monitoring Program (Rich Fadness and Mike Thomas, North Coast Water Board)

BOARD ACTION: This is an informational item, only. No action will be taken by the Regional Water Board.

BACKGROUND: Cyanobacteria, commonly known as blue green algae, are natural components of healthy marine and freshwater ecosystems. Cyanobacteria become harmful when planktonic or benthic forms proliferate, or bloom, and produce cyanotoxins at concentrations that can impact human and animal health. Planktonic or floating blooms in lakes and large rivers have been well-researched and have thresholds that have been developed for the protection of human and animal health. Less is known about benthic blooms of cyanobacteria that form mats on the bottom substrate of waterbodies. Benthic cyanobacterial blooms are less recognizable and require additional research to develop comparable thresholds.

Benthic cyanobacterial blooms in California's North Coast Region pose a health risk to animals and the recreating public. Between 2001-2021, there have been 18 suspected or documented dog deaths in the North Coast Region attributed to benthic cyanobacterial harmful algal blooms (cyanoHABs). In response to these deaths, North Coast Regional Water Quality Control Board (Regional Water Board) staff developed a monitoring plan to better understand benthic cyanobacterial growth and cyanotoxin production in the mainstem Eel, South Fork Eel, and Russian Rivers. Extensive monitoring was conducted from 2016 to 2019 to determine: 1) what cyanobacterial genera are responsible for the formation of toxic benthic mats; 2) what cyanotoxins are being produced; 3) which cyanotoxins are associated with the various mat-forming cyanobacterial genera; and 4) what are the spatial and seasonal patterns to mat formation and cyanotoxin production.

The findings of this study have been documented in the peer-reviewed report "Benthic Cyanobacteria and Cyanotoxin Monitoring in Northern California Rivers, 2016-2019" available on the Regional Water Board's website. (https://www.waterboards.ca.gov/northcoast/water_issues/programs/swamp/pdf/20220208_Final_North_Coast_Benthic_Cyano_Report_2016-2019_ADA.pdf). The findings will be used to inform the development of benthic cyanobacterial monitoring programs and to inform public health agencies and water resource managers of the recommended tools and methodologies for benthic cyanobacterial monitoring.

Although this report documents the presence of cyanobacteria, cyanotoxins, and their spatiotemporal patterns in the study rivers, further research is needed to identify the environmental conditions and controllable factors that influence benthic bloom development.

DISCUSSION:
Staff conducted visual assessments of sample sites, collected ambient water column grab samples, cyanobacterial mat samples, and deployed Solid Phase Adsorption Toxin Tracking (SPATT) passive samplers to characterize the occurrence and diversity of cyanobacteria and cyanotoxins and answer the monitoring questions.

A high-level answer to the four monitoring questions is presented below, with more detailed discussions available in the report.

1) What cyanobacterial genera are responsible for the formation of toxic benthic mats in the Eel, South Fork Eel, and Russian Rivers?

   Six benthic cyanobacterial genera were found to form toxic macroscopic mats in the three rivers: Anabaena, Cylindrospermum, Microcoleus (Phormidium), Nostoc, Oscillatoria, and Scytonema. Other toxic cyanobacterial genera may be present in lower densities within macroscopic mats.

2) What cyanotoxins are being produced in the Eel, South Fork Eel, and Russian Rivers?

   Samples were evaluated for five cyanotoxin and all five were detected in the three rivers, but detection rates and cyanotoxin concentrations varied by site and sample type (i.e., benthic mat, ambient water column, or SPATT samples). Anatoxins (a neurotoxin) and microcystins/nodularins (liver toxin/neurotoxin) were the most frequently and widely detected cyanotoxins, occurring in each river and at every sampling site from 2016 to 2019.

3) Which cyanotoxins are associated with the various mat-forming cyanobacterial genera?

   The six mat-forming cyanobacterial genera collectively produced all five cyanotoxins. Mats dominated by Anabaena, Microcoleus (Phormidium), and Oscillatoria frequently produced the highest concentrations of cyanotoxins. Concentrations of anatoxins were highest in benthic mat samples, while microcystins/nodularins were highest in water column samples.

4) What are the spatial and seasonal patterns to mat formation and cyanotoxin production in the Eel, South Fork Eel, and Russian Rivers?

   Mat-forming benthic cyanobacteria were identified at all sampling sites in the three rivers. In general, benthic cyanobacterial biomass increases from June through September, followed by a decrease in October.

Using multiple monitoring approaches, the Regional Water Board identified several toxigenic cyanobacteria of concern, most notably Anabaena, Microcoleus (Phormidium), and Oscillatoria. While low concentrations of all measured cyanotoxins were found in the water column, anatoxins, a class of potent neurotoxins produced by cyanobacteria, were determined to frequently occur at high concentrations within benthic mats. Cyanobacterial growth and cyanotoxin production occurred throughout all sampling sites in the Eel, South Fork Eel, and Russian Rivers, and increased during the summer months until early fall.

The Regional Water Board assessed the efficacy of several sampling techniques and recommends a stepwise approach for benthic cyanobacterial monitoring. Visual surveillance of toxigenic cyanobacterial mats should be employed as a primary tool for monitoring potential health risks in riverine systems, focusing on benthic mats dominated by Anabaena, Microcoleus (Phormidium), and Oscillatoria. Additionally, SPATT samplers should be deployed throughout a river beginning early in the season to document when dissolved cyanotoxins are present and increasing in concentration. As cyanotoxin concentrations in the SPATTs increase and visual observation documents the proliferation of mat forming toxigenic benthic cyanobacteria, cyanotoxin testing of mats should be employed to determine the potential health risks associated with river recreation. Riverine cyanotoxin monitoring programs should focus on anatoxins due to their prevalence. To document more fully the potential risk of exposure to humans and animals through ingestion of mat material, laboratory cyanotoxin analysis should rely on the ELISA method since it provides a more cumulative measurement of cyanotoxin congeners.

Additional Research and Study Recommendations

Future studies should investigate the best approach to standardizing data collection and lab assessment to determine cyanotoxin concentrations in benthic mats for the evaluation of human health, domestic animal, and wildlife protection. Additional studies should refine sampling protocols for SPATT samplers.

Benthic trigger levels for public health alerts could be developed that associate percent cover or toxigenic cyanobacterial biomass and cyanotoxin concentrations that would pose a threat to the public, domestic animals, and wildlife. Future studies should also focus on the long-term (seasonal) environmental conditions that are supportive of toxigenic cyanobacterial growth and how they are influenced by biostimulatory conditions and other potentially controllable factors.

This study and our Regional Benthic Cyanobacteria Monitoring Program was funded through the Regional Surface Water Ambient Monitoring Program (SWAMP) prior to the passage of Assembly Bill 834 and establishment of the State's Freshwater and Estuarine Harmful Algal Bloom (FHAB) Program in 2020. Many of the lessons learned from this study have already been incorporated in the Statewide program.

The purpose of this informational item is to present the findings of the report and the report's recommendations for implementing an effective benthic cyanobacteria monitoring program for the protection of public health. The report's recommendations are applicable to any waterbody, in any location. The only requisite change to implementation would be an understanding of the local conditions (e.g. cyanotoxin or cyanobacteria of concern).

RECOMMENDATION: N/A This is an informational item only.

SUPPORTING DOCUMENTS:

1. Report: Benthic Cyanobacteria and Cyanotoxin Monitoring in Northern California Rivers, 2016-2019.

   https://www.waterboards.ca.gov/northcoast/water_issues/programs/swamp/pdf/20220208_Final_North_Coast_Benthic_Cyano_Report_2016-2019_ADA.pdf