SWAMP Surface Water Ambient Monitoring Program

Central Coast Region | Report

# OCCURRENCE OF BLUE GREEN ALGAE TOXINS IN CENTRAL COAST STREAMS

## Introduction

Blue green algae or cyanobacteria are commonly found in freshwater, brackish, and marine environments all over the world. Cyanobacteria species of concern are those that are referred to as toxigenic species, or those that have the potential to produce toxins such as microcystins which can cause liver damage, affect the nervous system and irritate the skin (World Health Organization, 1999 and Office of Environmental Health Hazard Assessment (OEHHA), 2012). Harmful cyanobacteria and their toxins, including microcystin-LR, were placed on the Candidate Contaminant List (CCL) by the United States Environmental Protection Agency in July 2012 (USEPA, 2012).

Humans, pets and livestock can be exposed to cyanotoxins in a variety of ways. Human exposure can result from recreating in contaminated water (swimming, boating etc.) or from eating fish that have accumulated toxin from their environment. Pets and livestock have died after drinking water contaminated with microcystin (Briand et al. 2003 and Stewart et al. 2008).

Cyanobacteria blooms, often caused by anthropogenic eutrophication of surface waters (i.e. nutrient enrichment causing algal blooms), represent a major ecological and human health problem. When cyanobacteria decay, they can release toxins into the water. The decaying process of cyanobacteria also consumes oxygen, can cause taste and odor problems for drinking water, and may degrade fishery habitats. Harmful cyanobacteria blooms can also impair boating activities by clogging channels and water filters.

California Water Boards
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Previous studies in the Monterey Bay area have provided evidence that freshwater systems are a significant source of cyanobacteria toxins in the marine environment and those toxins are bioaccumulating in marine mammals in the near shore area. Twenty-one sea otters found dead or dying along the shores of Monterey Bay, between 1999 and 2008, had evidence of liver disease and tested positive for microcystin toxins. These findings prompted a study investigating the land-sea flow and trophic transfer of microcystin from inland surface waters to marine invertebrates and ultimately to marine mammals (Miller et al., 2010).

Monitoring for the presence of microcystin toxins in watersheds flowing into Monterey Bay had identified microcystins during cyanobacteria bloom events. Pinto Lake and its drainage into Corralitos Creek and the Pajaro River all tested positive for microcystin variants and provided results that determined the main source of toxins in Monterey Bay is not of marine origin (Kudela, 2011). Dr. Kudela used Solid Phase Adsorption Toxin Tracking (SPATT) samplers in his study (Figure 1). In a follow up study, the Central Coast Water Board's Ambient Monitoring Program (CCAMP) used SPATT samplers to test for the presence of cyanotoxins in the lower reaches of 31 coastal streams and rivers between Santa Clara County and Santa Barbara County (Figure 2).

## Methods

CCAMP paired cyanotoxin monitoring with routine monitoring efforts at targeted sample stations where samples are collected monthly and analyzed for nutrients, chlorophyll-a and other conventional parameters. Thirty-one long term trend stations located at the lower end of our Region's largest coastal watersheds were selected for the deployment of SPATT samplers in the Fall of 2011. Many of these coastal watersheds terminate at beaches where the coastal lagoons are heavily used for recreation and are often sensitive habitat for threatened and endangered species.

The initial SPATT deployment coincided with routine monitoring in August of 2011. CCAMP staff retrieved those SPATT samplers four weeks later, during a routine monitoring event, and deployed new SPATT samplers at that time. SPATT samplers were retrieved from each site in September, October and November of 2011.

The SPATT samplers are constructed from plastic embroidery hoops and two sheets of 100 micron Nitex blotting cloth that enclose three grams of HP20 Diaon resin beads (Figure 1). The resins adsorb and accumulate specific toxins for the duration of their deployment and therefore provide an integrated sample.

SPATT resins are analyzed at the Kudela Laboratory of Biological Oceanography at the University of California, Santa Cruz using LC-MS (liquid chromatography tandem mass spectrometry) for microcystin toxins using methods described in Mekebri et al. 2009 and Kudela, 2011. Using this method, the concentration of four microcystin variants was determined in nanograms of toxin per gram of resin. SPATT results do not yield water column toxin concentrations (i.e. ug/L) but are very useful to determine


**Figure 1. Photograph of a SPATT sampler next to a 4oz sample bottle.**

presence of toxins. Grab samples are needed to determine instantaneous concentration of each toxin in the water column. Microcystin variants detected in this study include microcystin-LR, microcystin-LA, microcystin-YR and microcystin-RR.

## Results

During the three-month study, at least one microcystin variant was detected in SPATT samplers at 20 of the 31 stations (Figure 2). At eight of the 31 stations, more than one microcystin variant was detected. Frequency of detection is difficult to compare between stations because some SPATT samplers were lost during deployment and therefore not retrieved for analysis. Ten of the 31 stations had at least one of the three SPATT samplers missing when field staff arrived to retrieve the SPATT.

Microcystin LR was the most common variant, detected at 15 of the 31 sites at least once during this study.

The October SPATT sampler collected from the Old Salinas River station had the highest microcystin concentration in this study. Again, this concentration is not the water column concentration but rather the concentration that accumulated in the resin over the 30-day deployment.

The site specific data are summarized in Table 1. For each site, Table 1 lists the frequency of microcystin occurrence as well the specific microcystin variants detected. In addition, the highest concentration, of microcystin per gram of resin, is reported for each site.

The Coastal Streams in the Central Coast Region span five Counties. Results are summarized by County below.

### *Santa Cruz and Santa Clara County Coastal Streams*

No microcystin toxins were detected in any SPATT samplers collected from Aptos Creek, Soquel Creek or Waddell Creek. Microcystin was detected in the November samples from Gazos Creek, San Lorenzo River and Scott Creek. The microcystin positive sample from San Lorenzo River had the highest concentration of the creeks in the County and contained three of the four microcystin variants analyzed. This finding may be of concern because the San Lorenzo River is a drinking water source for the City of Santa Cruz and a nitrate TMDL is in place for the River.

### *Monterey County Coastal Streams*

Eight of the ten Monterey County coastal streams included in this study tested positive at least once for a microcystin variant. The Pajaro River establishes the Santa Cruz / Monterey County line but is discussed with the Monterey County streams here. Two of the three SPATT samplers deployed in the Pajaro River were missing upon retrieval but a single SPATT sampler retrieved was positive for three microcystin variants. Historically, this Pajaro River station is characterized by elevated nutrients, wide swings in diurnal dissolved oxygen and very high concentrations of water column chlorophyll a.

Farther south, in the lower Salinas watershed, all three of the following sites are characterized by elevated nutrients and eutrophic conditions. None of the three SPATT samplers collected from the Salinas River or the Tembladero Slough tested positive for microcystin. However, the Old Salinas River SPATT samplers had high concentrations of microcystin in two of the three sample events with the October 2011 sample having the highest concentration of microcystin per gram of resin measured in this study (9.83 ng/g, Table 1).

Along the Big Sur Coast, four streams were included in this study. One of the three SPATT samplers from Big Creek contained low levels of microcystin-RR. Each of the other three sites sampled tested positive for microcystin variants

**Figure 2. Coastal Watershed stations sampled for Microcystin presence. Green = No Microcystin detected. Yellow = detected in one event. Orange = detected in two events. Red = detected in three events. White = not sampled for Microcystin.**

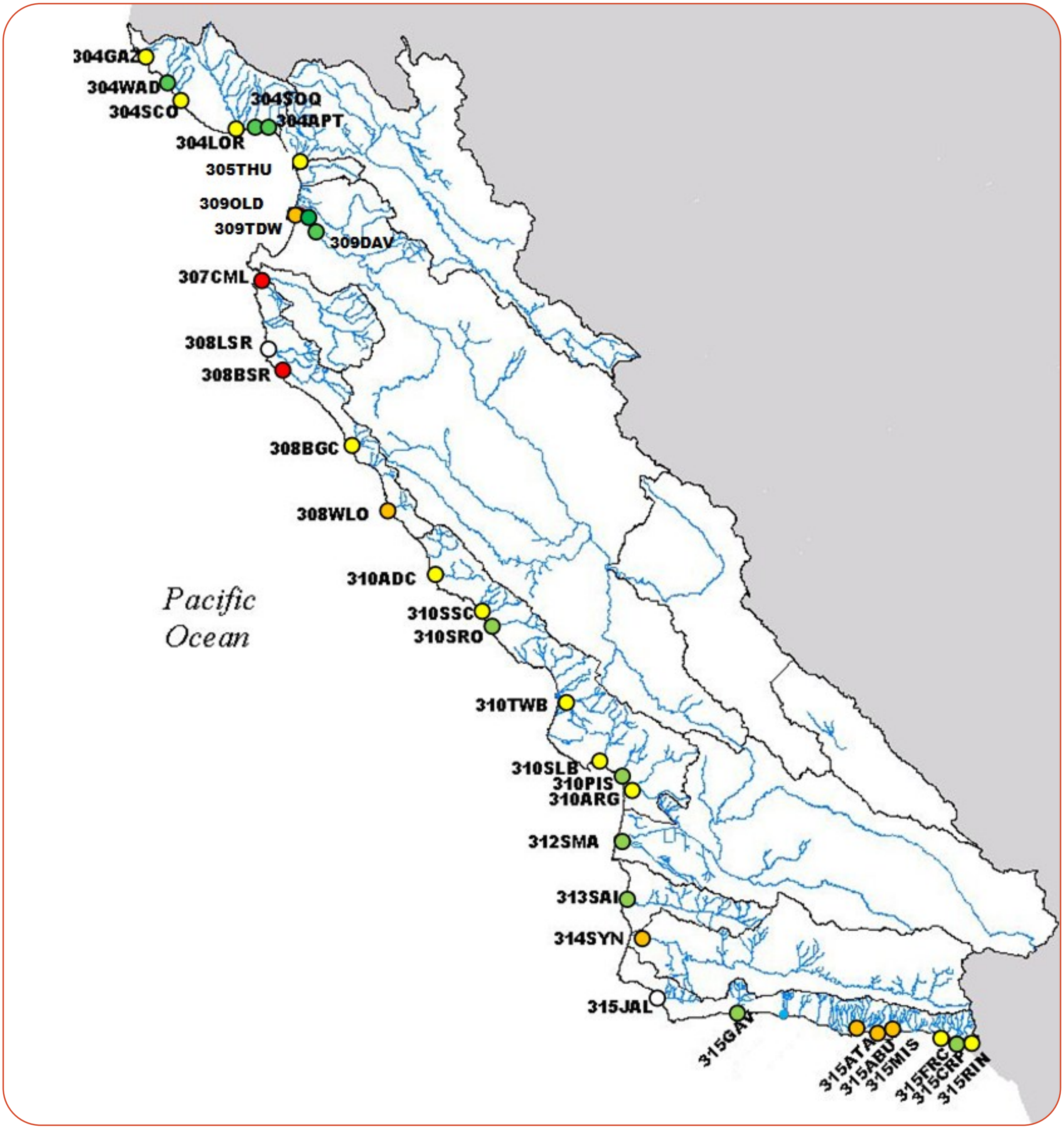

**Table 1. Site specific microcystin data summary. An X indicates microcystin detection. Green = No microcystin detected. Yellow = detected in one event. Orange = detected in two events. Red = detected in three events.**

| Station Name | Station Code | Sep-11 | Oct-11 | Nov-11 | Variants Detected | Max [Conc] (ng/g) |
|---|---|---|---|---|---|---|
| Gazos Creek | 304GAZ | | | X | LR | 0.74 |
| Waddell Creek | 304WAD | SPATT missing | | | None | NA |
| Scott Creek | 304SCO | SPATT missing | SPATT missing | X | RR | 0.55 |
| San Lorenzo River | 304LOR | | SPATT missing | X | LA, LR, RR | 1.25 |
| Soquel Creek | 304SOK | | | | None | NA |
| Aptos Creek | 304APT | | SPATT missing | | None | NA |
| Pajaro River | 305THU | SPATT missing | SPATT missing | X | LA, LR, & RR | 2.37 |
| Old Salinas River | 309OLD | | X | X | LA & LR | 9.83 (Oct) |
| Tembladero Slough | 309TDW | | | SPATT missing | None | NA |
| Salinas River | 309DAV | | | | None | NA |
| Carmel River | 307CML | X | X | X | LR | 1.51 (Oct) |
| Big Sur River | 308BSR | X | X | X | LR & RR | 1.56 (Oct) |
| Big Creek | 308BGC | | | X* | RR | 0.12 *DNQ |
| Willow Creek | 308WLO | X | X | SPATT missing | LR & RR | 3.58 (Sep) |
| Arroyo de la Cruz | 310ADC | | X | SPATT missing | RR | 5.9 |
| San Simeon Creek | 310SSC | | | X | LA & RR | 1.46 |
| Santa Rosa Creek | 310SRO | | | | None | NA |
| Chorro Creek | 310TWB | X | | | LR | 2.053 |
| San Luis Obispo Creek | 310SLB | | X | | RR | 1.45 |
| Pismo Creek | 310PIS | | | | No | NA |
| Arroyo Grande | 310ARG | | X | | LR | 4.66 |
| Santa Maria River | 312SMA | | | | None | NA |
| San Antonio Creek | 313SAI | | | | None | NA |
| Santa Ynez River | 314SYN | | X | X | LA, LR & RR | 2.84 (Nov) |
| Gaviota Creek | 315GAV | | | | None | NA |
| Atascadero Creek | 315ATA | X | | X | LA, LR & RR | 1.418 (Sep) |
| Arroyo Burro | 315ABU | X | | X | LA, LR & RR | 0.758 (Sep) |
| Mission Creek | 315MIS | X | X | | LA, LR & RR | 0.942 (Sep) |
| Franklin Creek | 315FRC | | X | SPATT missing | LA & LR | 2.79 |
| Carpinteria Creek | 315CRP | | | SPATT missing | None | NA |
| Rincon Creek | 315RIN | | | X | LA & LR | 1.84 |

more frequently; All three events at the Carmel and Big Sur Rivers and both of the Willow Creek events (one SPATT was missing upon retrieval). Historic water quality data from these four Big Sur coastal streams indicate high quality with low nutrients and stable, healthy oxygen levels.

### *San Luis Obispo County Coastal Streams*

Microcystin was not detected in any of the SPATT samplers collected from Santa Rosa or Pismo Creeks. Five of the seven streams tested positive for microcystins in one of the sample events. Those streams include Arroyo de la Cruz, San Simeon Creek, Chorro Creek, San Luis Obispo Creek and Arroyo Grande. With the exception of Arroyo de la Cruz, each of these creeks are characterized by elevated nutrients, filamentous algal blooms in the summer and eutrophic conditions. Furthermore, San Simeon, Chorro and San Luis Obispo Creeks are downstream of municipal waste water treatment plants which either discharges to surface water or percolation ponds in the lower watersheds.

### *Santa Barbara County Coastal Streams*

Ten Santa Barbara County waterbodies were included in the study and six of these tested positive for microcystin in one or more events. Rincon and Franklin creeks tested positive for microcystin in one sample each. In the Santa Ynez River, Arroyo Burro, Atascadero Creek and Mission Creek, two of three SPATT samplers tested positive for microcystin variants. In each of the previously mentioned waterbodies, three microcystin variants were identified. In addition, all ten of the Santa Barbara waterbodies include in this study exhibit some level of eutrophication in summer and fall months, also coincident with reduced flows. Elevated nitrogen levels (greater than 5 mg/L) are routinely detected in the Santa Maria River, San Antonio Creek, Santa Ynez River and Franklin Creeks. However, no microcystin variants were detected in Santa Maria River, San Antonio Creek, Gaviota Creek or Carpinteria Creek.

## Conclusions

Results from the screening study show microcystin is present in the lower ends of 65% of the central coast watersheds tested. Microcystin toxins were detected in creeks with water quality ranging from poor to very good. There is no clear connection with occurrence of microcystins and land use activities or geography. For example, the highest concentration was measured in the Old Salinas River site, which is heavily impacted by agriculture but no microcystins were detected at a station that is hydrologically connected and located 500m away.

## Follow Up

The current study shows presence of cyanotoxins throughout the coastal streams of the Central Coast but does not quantify the concentrations in the water column. Water Board staff are currently proposing a follow up study to evaluate both the presence and magnitude (water column concentration) of microcystin in the Region. These additional data will inform assessments of beneficial use attainment and will inform recommendations to permit staff (i.e. NPDES and AG programs) for future permit revisions.

## Collaborators


- Bay Foundation of Morro Bay provided management of the CCAMP endowment funds which were used to fund the analysis and field staff.
- The Kudela Laboratory of Biological Oceanography at the University of California, Santa Cruz provided all laboratory analysis and SPATT sampler supplies used in this study.


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