The Impact of the 2014 Severe Drought on Microcystis Blooms in the San Francisco Estuary

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Microcystis blooms have occurred in the San Francisco Estuary since 2000 and are important to estuarine production, because they adversely affect the health and survival of phytoplankton, zooplankton and fish. *Microcystis* blooms are expected to increase over time in association with the increased frequency and intensity of drought with climate change. To gain more knowledge on how drought can impact these blooms, an intensive *Microcystis* field sampling program was conducted during the 2014 severe drought. The 2014 drought was characterized by a 66% to 85% reduction in streamflow during the summer and significantly increased the amplitude and duration of the *Microcystis* bloom and its ecological impact. *Microcystis* biomass increased by two orders of magnitude over previous dry years and was accompanied by elevated levels of the toxin microcystin-LR. The persistence of warm water temperature extended the *Microcystis* bloom into December, two months longer than previous blooms. The bloom was associated with extreme water quality conditions, including a 20 year high in soluble phosphorus and low in ammonium concentration. Correlations suggest the bloom varied with both inorganic and organic nutrient sources as well as environmental conditions. Biological impacts included a shift in the *Microcystis* species, increased abundance of other toxic cyanobacteria and adverse impacts to fish survival.

Keywords: Microcystis, drought, toxins, cyanobacteria bloom

Poster Topic: The Microcystis Bloom during the 2014 Drought

Drought Enhances Abundance and Biodiversity of Cyanobacteria in the Sacramento-San Joaquin Delta

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Severe cyanobacterial blooms are one of many environmental risk factors associated with drought impacts in the Sacramento-San Joaquin Delta. This study focused on molecular analyses of ambient water collected from the Delta during August to December of 2014, a record drought year. The samples were analyzed by quantitative PCR (qPCR) to quantify recurring key cyanobacteria and by Next Generation Sequencing technology to identify emerging cyanobacterial species in the environment (i.e. eDNA). The qPCR results showed prolonged blooms of *Microcystis aeruginosa* up to September; the magnitude was approximately 7.7 times higher compared to 2013, a moderately dry year. In addition, blooms of *Aphanizomenon flos-aquae* were prominent in 2014: the abundance of *A. flos-aquae* was over 30,000 cells per ml in August 2014 while in 2013, this species was barely observed. Interestingly, the presence of DNA sequence encoding the toxin-synthetase gene of *Anabaena* sp. was identified by eDNA analysis. To the best of our knowledge, this is the first report on the occurrence of potentially toxin producing *Anabaena* sp. in the Sacramento-San Joaquin Delta. We are currently developing specific qPCR assay for the toxin-synthetase gene of *Anabaena* sp. to investigate their temporal and spatial distribution. These results indicate that severe drought conditions provide favorable environment for *Microcystis aeruginosa*, *Aphanizomenon flos-aquae*, and other emerging cyanobacterial species that potentially impact aquatic organisms and ecosystems in the Delta.

Keywords: Drought, Cyanobacteria, qPCR, NGS

Poster Topic: The Microcystis Bloom during the 2014 Drought

Water Quality Issue during Drought Year in the Sacramento-San Joaquin Delta

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Drought is impacting the aquatic environment. To evaluate the impacts on aquatic organisms, we performed fish embryo toxicity testing using medaka (*Oryzias latipes*) with the surface water collected from the Sacramento-San Joaquin River Delta during August and September of 2014, a record drought year. High mortality rate was observed in the surface water collected at San Joaquin River, Franks Tract, Mildred Island, Jersey Point, and Liberty Island (>70%) while mortality was barely recorded at Antioch and Collinsville (<10%). Embryos incubated in the surface water exhibited characteristic features: embryos became yellowish in color and egg shells became thinner and softer. Some embryos exhibited exclusion of a portion of egg yolk or whole body from the shells before completion of embryonic development (<5%). In addition, growth of microscopic organisms (bacteria or protozoa) was occasionally observed. The water physical parameters such as pH, nitrate, and ammonia concentrations were within normal ranges, therefore we speculate that the mortality was likely because of contaminants. The exact cause of mortality is still unknown. Another drought is forecasted in 2015, suggesting we will likely experience similar water quality issues in the Sacramento-San Joaquin River Delta. To understand the impacts of drought on aquatic environment and protect aquatic organisms, we propose to formulate plans for testing and measurement of water quality using various endpoints.

Keywords: Drought, Fish Embryo, Toxicity, Water Quality

Poster Topic: The Microcystis Bloom during the 2014 Drought

Changes in Zooplankton Composition and Abundance during the 2014 Microcystis Bloom

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2014 was one of the driest years on record in California, resulting in increased residence times and water temperatures in the San Francisco Estuary. Such conditions are favorable for cyanobacterial harmful algal blooms (CHAB), including *Microcystis aeruginosa,* a known toxic cyanobacteria. A drought response study investigated the distribution, abundance, genetic composition, toxin production and food web impact of *Microcystis spp.* in the San Francisco Estuary. The goal of this study was to determine the abundance and distribution of key zooplankton taxa as it relates to *Microcystis spp.* blooms during the critical drought year 2014. *Microcystis spp.*, zooplankton, water quality, and ambient water samples were collected biweekly from ten stations in the San Francisco Estuary from July to December 2014. Zooplankton samples were preserved in 70% ethanol and were identified by taxa and enumerated for biomass using a FlowCAM digital imaging flow cytometer. Results showed that copepod and cladoceran species were the most abundant zooplankton present during the CHAB. Data suggests that sites along the inner delta yielded the highest biomass and diversity. These findings are significant as *Microcystis spp.* may have adverse impacts on the Sacramento-San Joaquin aquatic food web.

Keywords: Zooplankton, Drought, Microcystis, Harmful Algal Bloom

Poster Topic: The Microcystis Bloom during the 2014 Drought