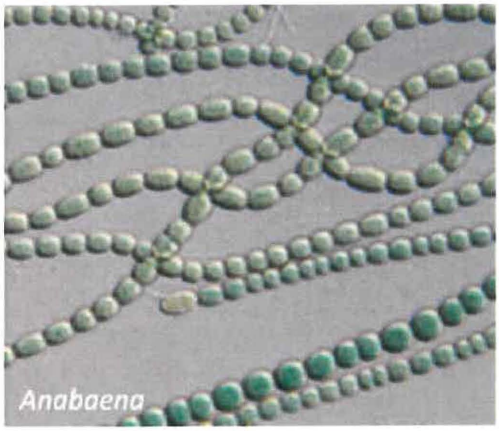
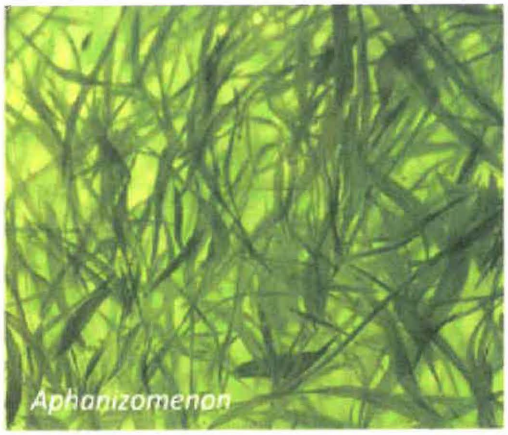
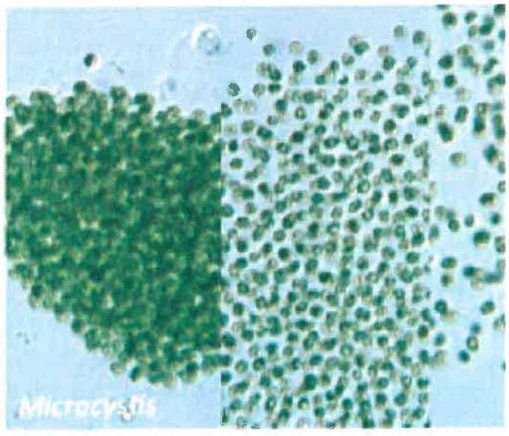
DWR-558

Factors Affecting Growth of Cyanobacteria

With Special Emphasis on the Sacramento-San Joaquin Delta







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phytoplankton, macrophytes, and benthic microalgae (Jeppesen *et al.* 2007, Paerl and Paul 2012). CyanoHABs also can cause night-time dissolved oxygen depletion via bacterial decomposition and respiration of dense blooms which results in fish kills and loss of benthic fauna (Paerl 2004, Paerl and Fulton 2006). At dense concentrations, mortality to aquatic animals such as sea otters, birds and seals may result from liver failure following ingestion of prey with high concentrations of toxin, or coming into physical contact with the toxin (Jessup *et al.* 2009, Miller *et al.* 2010). Humans coming in contact with the water may develop digestive and skin diseases (Section 2.2.6) and it may affect the drinking water supplies (Cheung *et al.* 2013). In the following sections, cyanoHAB abundance and toxin levels in the Delta vis-à-vis published guidance on alert levels are summarized in order to place the threat of cyanoHABs in the Delta into context.

4.2 Prevalence and Trends of CyanoHABs in the Delta

Since 1999 blooms of the toxin producing cyanobacteria *Microcystis aeruginosa* in the Delta have been observed by the Department of Water Resources (DWR), and have been reported in the scientific literature. In the beginning, only blooms of *Microcystis* were observed; these were documented visually appearing as little flakes of lettuce in the water (Lehman and Waller 2003). Later investigations (post 2005) employing microscopic enumeration and molecular characterizations have documented blooms comprised of a mix of *Aphanizomenon* sp. and *Microcystis*, with *Anabaena* sp. also present in much smaller densities (Lehman *et al.* 2010, Mioni *et al.* 2012).

While environmental indicators such as salinity, turbidity, temperature, total phytoplankton biomass (as Chl *a*), and phytoplankton species composition are monitored on a monthly basis by DWR, surface concentrations of cyanobacteria and cyanotoxins, which require special sampling, are not routinely monitored. As such, the information on the chronology of cyanoHAB occurrences presented here is taken from a handful of publications and reports, and varies somewhat in geographical extent according to where the authors sampled. Because *Aphanizomenon* and *Anabaena* densities have only been documented for two time points, the following sections will focus on *Microcystis* biomass and microcystin toxin concentrations. Additionally, these sections will focus on aquatic health rather than human health whose risks may be better evaluated from sampling of surface scums.

4.2.1 Spatial Distribution of Microcystis throughout the Delta

The Central Delta, between Antioch and Mildred Island, is typically the region with the highest surface *Microcystis* and *Aphanizomenon* concentrations. In 2003, the stations with the greatest recorded abundance of Chl *a* due to *Microcystis* (as determined by horizontal surface tows with a 75-µm mesh plankton net) were Jersey Point (D16), Mokelumne River Mouth and Navigation Marker 13 in the San Joaquin River, followed by San Mound Slough, Mildred Island, (D29) and Rancho del Rio (D28) in Old River (Figure 4.1). In following years, greatest abundance of

Microcystis has repeatedly occurred in the same areas in the San Joaquin and Old Rivers (Lehman *et al.* 2008, Mioni *et al.* 2012, Lehman *et al.* 2013). In 2012, abundant *Microcystis* colonies were also observed in the South-East Delta region in the Turning Basin of the Stockton Shipping Channel (Spier *et al.* 2013). Moving west from Antioch into Suisun Bay, *Microcystis* abundance decreases substantially to almost non-detectable by Chipps Island (Lehman *et al.* 2005, 2008, 2010). The same holds true when moving north where abundances detected at Antioch decline to almost zero by Collinsville at the entrance of the Sacramento River (Figure 4.1).

Whether or not the spatial distribution of *Microcystis* and other cyanoHAB species is affected favorably or unfavorably by concentrations of herbicides entering the Delta as run-off, or from the Sacramento and San Joaquin Rivers is not known. Recent reports suggest that a broad swath of herbicides and fungicides associated with agriculture is present at concentrations high enough to affect aquatic life (Orlando *et al.* 2014). As such, the impact of herbicides common to the Delta in selectively promoting certain phytoplankton species, including possibly cyanoHAB species, may deserve greater attention.

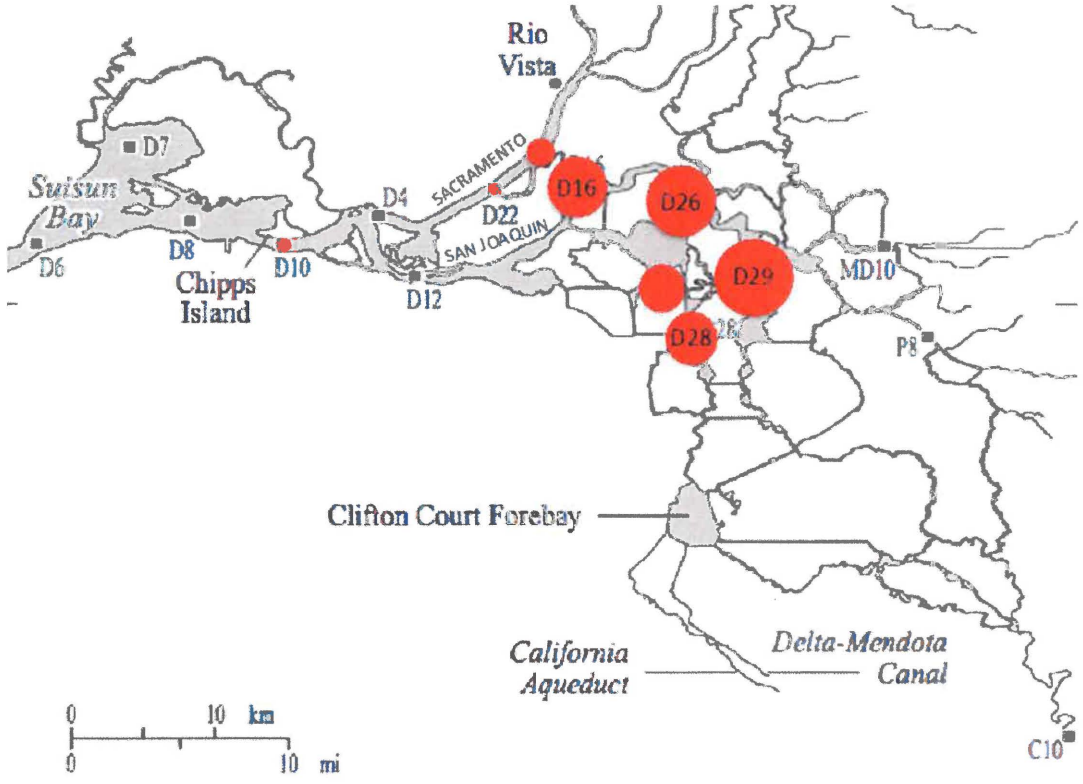

Figure 4.1. The Sacramento-San Joaquin Delta Region. Red bubbles mark locations with greatest Microcystis-associated surface Chl a concentrations (largest bubble=0.55 µg Chl a L^{-1}). Data from Lehman *et al.* 2005.