Deterioration of Water Quality Linked to Climate Change

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Abstract

Background: Currently water availability is stressed in many regions and this is expected to increase worldwide. Global climate change can degrade water quality by increasing salinity, reducing influx of freshwater, and causing cyanobacterial blooms. Previous work has shown that growth of toxin-producing cyanobacteria in drinking water supplies poses significant human health risks. Our work looks at the effects of these changes on biodiversity.

Hypothesis: As an aquatic ecosystem is exposed to increasing temperatures and decreased freshwater flow, cyanobacterial growth will increase, and biodiversity will decrease.

Materials/Methods: A microaquarium, originally filled with water from Crystal Springs Reservoir, was observed for six months. Observations regarding population density, succession, and species diversity were recorded and analyzed.

Results: After a series of rapid population successions, the primary producers changed from diatoms to cyanobacteria with a concomitant decrease in diversity of protozoa and invertebrates.

Conclusions: Increased temperature, low freshwater flow, and nutrient accumulation is correlated with a cyanobacterial bloom and loss of species diversity. The microaquarium environment may serve as a model for potential consequences of climate change, as it relates to global biodiversity and the water crisis.

Aim

To measure the effects of decreased freshwater flow on an aquatic ecosystem

Background

- Eutrophication is a threat to the quality, safety and sustainability of our water resources worldwide (1,6).
- Freshwater cyanobacteria produce potent cyanotoxins which can affect vertebrates and protozoa (1,2,7).
- Aquatic conditions including warm weather, low turbulence or reduced vertical mixing, and high nutrient levels can stimulate rapid cyanobacteria growth, or "blooms." When blooms are formed, toxins are produced, contaminating surface waters (7).
- Warmer temperatures support maximal growth of cyanobacteria more than competing eukaryotic algal producers and dinoflagellates (1,4).
- Cyanobacterial blooms negatively affect aquatic ecosystems by altering light availability in the water column, and their decomposition can cause excessive oxygen consumption (7).
- Thus cyanobacterial blooms indicate advanced eutrophication in freshwater lakes and reservoirs.
- Cyanobacterial blooms are toxic to many animals, including humans (5,6).
- Long term management of water quality and availability must consider climatic factors affecting cyanobacterial blooms and their impact on the freshwater supply.

Methods

- A 6.6 cm × 4.7 cm × 2 mm wide microaquarium (Carolina Biological), originally filled with 5.5 mL water and sediment from Crystal Springs Reservoir, was observed for six months (**Figure 1a**).
- Evaporative loss was replaced with distilled water on a biweekly basis.
- pH of the water was measured with pH paper (Whatman pH indicator type CF, 1-14).
- Total nitrogen was determined by a nitrate, nitrite, and ammonia test kit (API Aquarium Pharmaceuticals).
- The predicted conditions of climate change, including reduced freshwater influx, stagnant water flow and increased temperatures were duplicated in the microaquarium (**Figure 1b**). The microaquarium was
  - not aerated.
  - was incubated indoors, in direct sunlight to provide a warmer than ambient temperature.
  - was not flushed. Detritus that accumulated was not removed.
- Observations regarding population density and species diversity were made using a Leica inverted microscope. General qualitative observations were made visually.

a. Day 0

b. Day 199

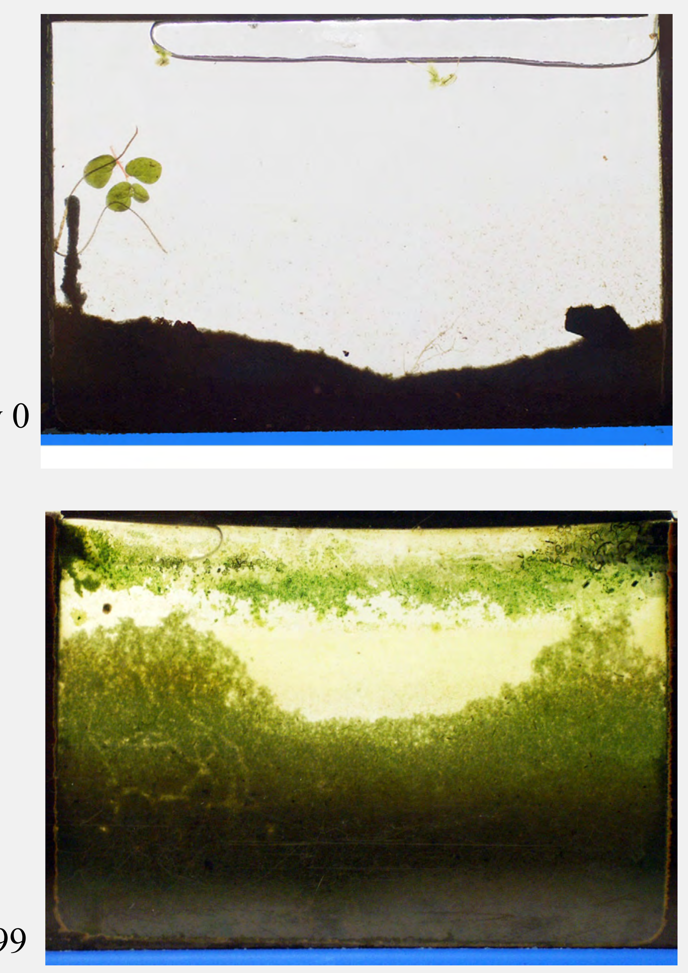

Figure 1. The microaquarium at **(a)** day 0, filled with water and sediment from Crystal Springs Reservoir. **(b)** Day 199. Note the cyanobacterial bloom and accumulation of detritus.

Results

•pH remained at 7 throughout the study period. The pH at the end of the experiment was 7.2.

•Denitrifying bacteria led to no NH_3, ≤5 ppm NO_3^- and cyanobacterial blooms (**Figure 1**).

•The succession of phytoplankton followed a seasonal progression: Diatoms are abundant in the spring followed by cyanobacterial dominance during the summer (**Figure 2**).

•Ostracods and copepods continue to dominate the microaquarium. These animals tolerate anoxic and eutrophic conditions (**Figure 3**).

•Overall biodiversity decreased over the study period (**Figure 4**).

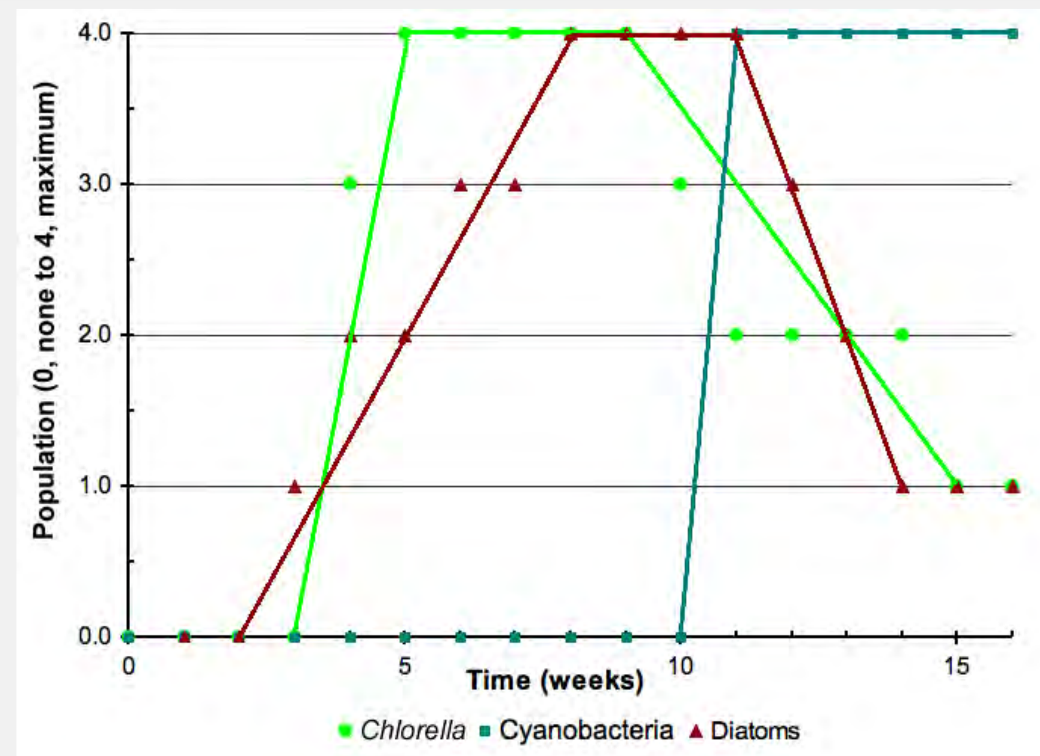

Figure 2. Succession of primary producers over 16 weeks. Diatoms were seen first and replaced by cyanobacteria at week 10.

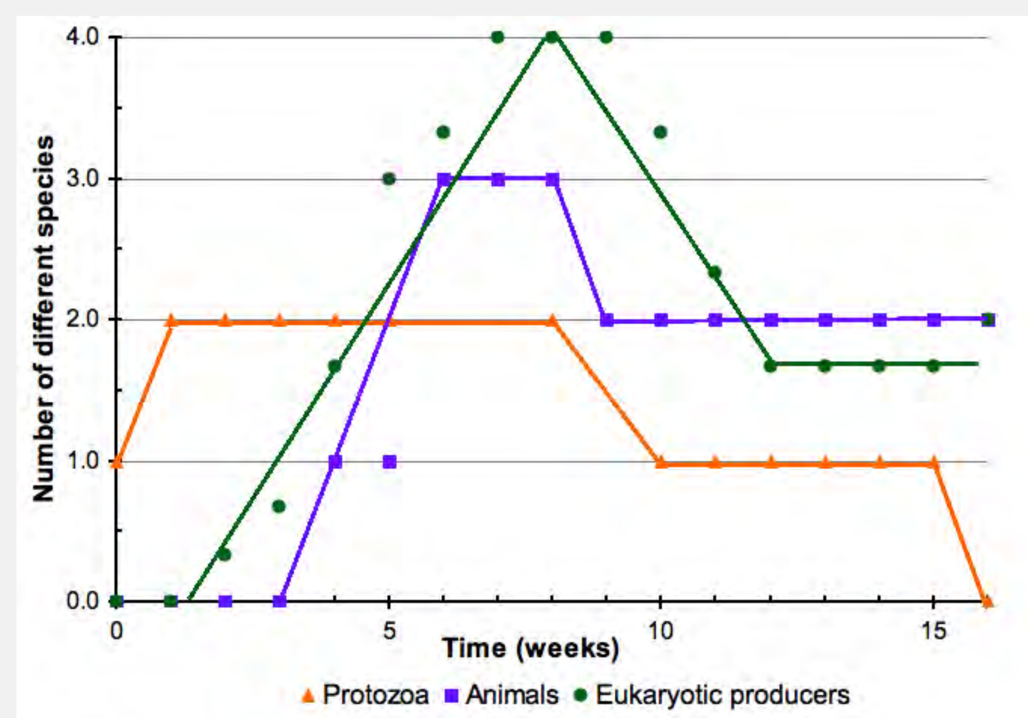

Figure 3. Succession in the microaquarium over 16 weeks. Protozoa decreased steadily, concomitant with a rise in animals (rotifers, ostracods, and copepods).

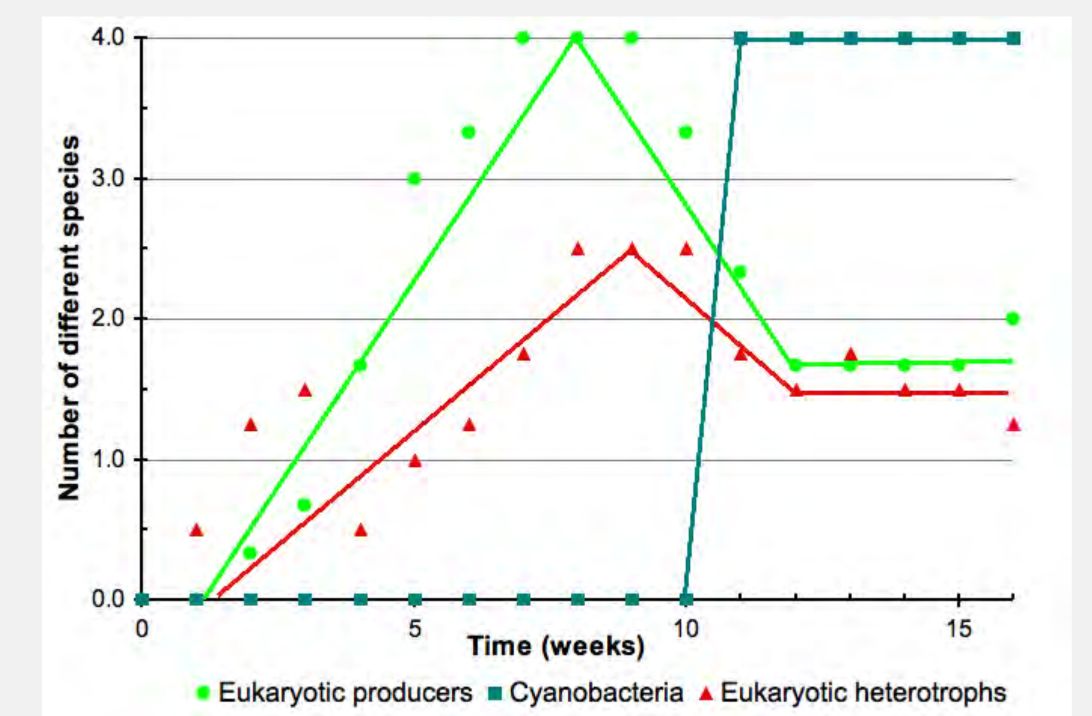

Figure 4. Biodiversity decreased over time. The rise in primary producers is due to species that tolerate eutrophic conditions.

Discussion & Conclusion

- Our observations are consistent with observed events in aquatic ecosystems, that is, warming and reduced water flow favor cyanobacterial blooms and bloom persistence.
- Our results confirm published predictions (7) that high biomass blooms can decrease biodiversity by suppressing zooplankton and animals.
- The microaquarium may be a useful method to study specific relationships in a changing environment.
- Our results suggest decreased biodiversity results from lack of influx of nutrients normally brought by rain run-off.

Literature Cited

1. Boqiang Q. et al. "*A Drinking Water Crisis in Lake Taihu, China: Linkage to Climatic Variability and Lake Management.*" *Environmental Management* (2010) 45:105-112
2. Bouvy, M. et al. "*Effects of Cyanobacterial Bloom (Cylindrospermopsis raciborskii) on Bacteria and Zooplankton Communities in Ingazeira Reservoir (Northeast Brazil).*" *Aquatic Microbial Ecology* (2001) 25: 215-227
3. Chorus, I. "*Toxic Cyanobacteria in Water: A Guide to Their Public Health Consequences, Monitoring and Management.*" World Health Organization. Saint Edmundsbury Press, St Edmunds, Sufolk. 1999.
4. Delpla, A. et al. "*Impacts of Climate Change on Surface Water Quality in Relation to Drinking Water Production.*" *Environment International* (2009) 35: 1225-1233
5. Marshall, J. "*In Summer, Toxic Blue Green Algae Blooms Plague Freshwater.*" http://cironline.org/reports/summer-toxic-blue-green-algae-bloom 4/4/2013
6. Murdoch, P. et al. "*Potential Effects of Climate Change on Surface Water Quality in North America.*" *Journal of the American Water Resources* Association (2000) 36: 2
7. U.S. Environmental Protection Agency. "*Cyanobacterial Harmful Algal Blooms.*" http://www2.epa.gov/nutrient- policy-data/cyanobacterial-harmful-algal-blooms-cyanohabs 4/1/13

Acknowledgements

This microaquarium observation project was originally a term requirement for Organismal Biology. Inspired by Rachael Carson's ***Silent Spring***, the aim of the project was to examine current environmental issues whose consequences parallel those outlined by Carson. The effects of widespread pesticide use detailed by Carson initiated a wave of environmental policies and raised public awareness.

Facing new environmental challenges, we are charged with repairing and preventing further damage to our aquatic environment, just as Carson did in the 1960s.

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