Contrasting diel patterns of water chemistry from three lakes in Indian Bend Wash

W.J. Roach and N.B. Grimm
Central Arizona-Phoenix LTER,
Department of Biology, Arizona State University, Tempe, Arizona

Abstract

Intense solar radiation and dramatic temperature fluctuations characterize Sonoran Desert summers. During the summer, air temperatures frequently fluctuate by more than 10 °C over the course of a day. In part because of the warm temperatures and abundant sunshine, many desert aquatic ecosystems are extremely productive, and this productivity has important consequences for water chemistry. We quantified diel fluctuations in water temperature and water chemistry in three urban lakes in Indian Bend Wash during July, 2001.

Introduction

We have been investigating the flow of nitrogen and phosphorus through Indian Bend Wash, a heavily modified urban watershed in Scottsdale, AZ. The physical structure of the lower portion of the wash is dominated by a string of small artificial lakes that were constructed in the larger protected floodplain (Fig. 1). Water levels in these lakes are maintained by water pumped directly from the ground and by diversions from the Arizona Canal. Periodic flooding also contributes water to the lakes. Previous research suggests that nutrient concentrations within the wash are largely a function of the distinct characteristics of these different water sources. However, it is also clear that the lakes themselves play an important role, with some lakes consuming nutrients while other appear to be sources (Fig. 2).

In July, 2001, we began to assess the effects of these lake specific dynamics by examining diel fluctuations in nutrient concentrations within the water column of three of these lakes. We collected depth-stratified samples from each lake six times between approximately 5:30 AM and 9:00 PM. We then compared vertical profiles of water temperature, dissolved oxygen, nitrate, ammonium and soluble reactive phosphorus for each time step.

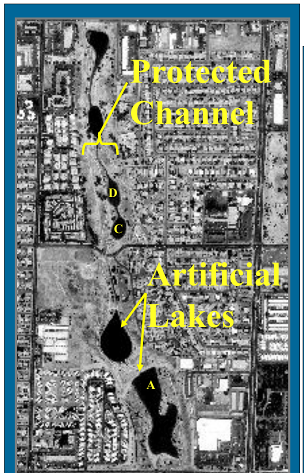

Fig. 5. Aerial photo of the artificial lakes in lower Indian Bend Wash. Note the width of the protected channel which may be entirely inundated during floods. Diel surveys were conducted in lakes A, C and D.

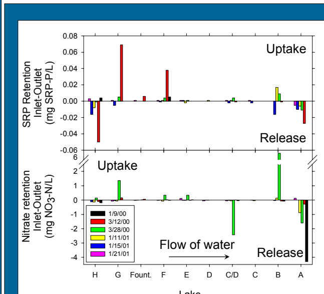

Fig. 2. Nutrient retention of eight lakes (and one fountain) on each of six sampling dates. Retention was calculated as the difference in nutrient concentration in the inflow and outflow of each of the lakes. On some dates, Lakes C and D were treated as one lake. Note that some lakes appear to be consistent nutrient sources while others appear to be consistent sinks.

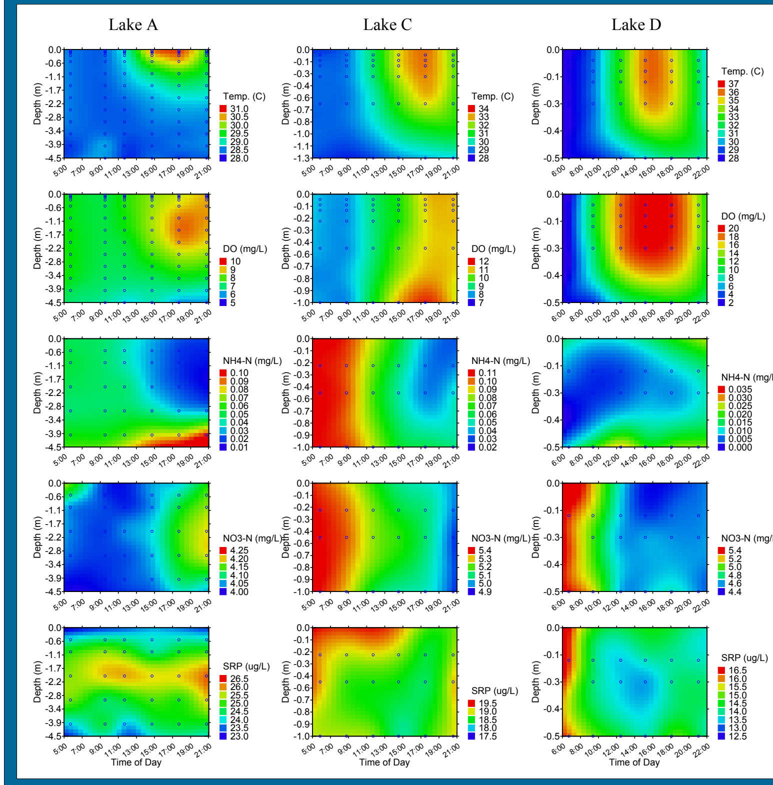

Fig. 3. Diel variation in the vertical profiles of temperature (Temp), dissolved oxygen (DO), ammonium (NH4-N), nitrate (NO3-N) and soluble reactive phosphorus (SRP) in Lakes A, C and D of Indian Bend Wash. Each column represents a lake while each row represents a variable of interest. The small blue circles indicate the depth and time each sample was collected. The colors represent values extrapolated or interpolated from these points. Please note the difference in the depths of each lake as well as the range of observed temperatures and nutrient concentrations. Also note that temperature and dissolved oxygen were sampled more closely together than were ammonium, nitrate or soluble reactive phosphorus. In addition to differing in their depth, the lakes differed in the relative importance of macrophytes versus phytoplankton. Lakes A and C were phytoplankton dominated while Lake D was macrophyte dominated, with macrophytes covering approximately 80% of the lake bottom.

Results

In all three lakes water temperature increased until about 5:00 PM, with surface water warming more rapidly than deeper water (Fig. 3). This increase was most pronounced in Lake D, the shallowest lake, which experienced temperature fluctuations as great as 8.4 °C.

Oxygen concentrations also increased (Fig. 3), presumably as a result of primary production. Once again, Lake D experienced the greatest rate of change, with oxygen concentrations increasing by nearly 20 mg/L over the course of the day.

Ammonium in Lakes A and C declined dramatically over the course of the day (Fig. 3). A similar but less pronounced decline was observed in Lake D. The decline in ammonium concentrations in lakes A and C was significantly inversely related to oxygen production (Fig. 4).

Results (cont.)

Nitrate concentrations varied less predictably. In Lake A, nitrate concentrations increased during the day (Fig. 3) and this increase was directly related to increases in oxygen (Fig. 4). Conversely, in Lake D, nitrate concentrations decreased over the course of the day (Fig 3) and this decrease was significantly inversely related to oxygen production (Fig. 4). Although nitrate concentrations also declined in Lake C (Fig. 3), these declines could not be explained by changes in oxygen (Fig. 4). However, there was a strong inverse relationship between absolute nitrate concentrations and dissolved oxygen (*not pictured*).

Soluble reactive phosphorus concentrations were low in each lake and showed no clear trends with time (Fig. 3) nor were changes in SRP concentrations associated with changes in dissolved oxygen (Fig. 4).

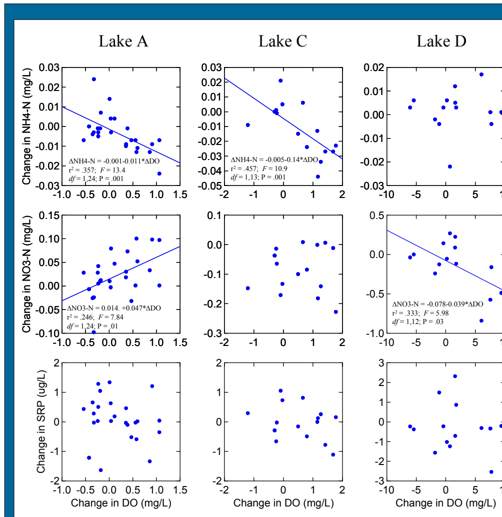

Fig. 4. Relationship between changes in dissolved oxygen and changes in nutrient concentrations in Lakes A, C and D. Once again, each column represents a lake while each row represents a nutrient (either ammonium, nitrate or soluble reactive phosphorus). In an attempt to control for temporal autocorrelation, the difference in nutrient concentrations at two adjacent time steps was plotted against the difference in dissolved oxygen concentrations for the same interval. Linear regressions were then performed to determine whether or not changes in nutrient concentrations could be predicted from changes in dissolved oxygen. Only significant regression lines have been plotted.

Conclusions

We hypothesize that the increases in oxygen concentrations and declines in nitrogen result from primary production and that differences between lakes are due in part to differences in depth and in part to differences in the relative importance of macrophytes versus phytoplankton.