

On April 9, 2008 two teams from Santa Barbara Channelkeeper (Ben, George, Penny and Al) measured diel variations in dissolved oxygen (DO) and *pH* at 11 locations on the Ventura River. Measurements were made either in the stream itself or from samples collected by bucket tossed from a bridge into the center of flow (bucket samples allow faster and easier measurement, especially at night). Pre-dawn measurements were made from 4:45 to 6:30 AM, afternoon measurements between 1:30 and 4:00 PM. The dissolved oxygen values recorded, along with differences between the two readings, are shown on the graph (as percent saturation). Site numbers indicate the regular Channelkeeper monitoring sites at which measurements were made; VR00 indicates samples collected along the east (e) and west (w) sides of the railroad causeway over the Ventura estuary. Algal growth produces a daily cycle in both DO and *pH*: daylight photosynthesis adds oxygen while removing carbon dioxide; nighttime respiration reverses the process. DO concentrations in the surrounding water typically peak around mid-afternoon and decline to a minimum just before sunrise. The magnitude of the change in DO reflects both the amount of algae (and the extent of their biological productivity, i.e., how hard they are working) and the amount of water in which this change in DO is reflected. A fixed amount of algae will produce increasingly greater changes in DO as the volume (or flow) of water decreases. And since the dominant alga at all these sites is currently *Cladophora*, which usually grows outward from a rock substrate, water depth is also a factor: the shallower the flow, the easier it is for algae to change its character.



April 9, 2008, from top to bottom and left to right: phytoplankton at VR00w; Main Street, VR01; Shell Road, VR03; Canada Larga, VR04; Foster Park, VR06; Matilija Creek, VR15.

The location with the greatest diel variation was lower San Antonio Creek (VR07; 70-180 % sat.), but all sites below the Ojai Treatment Plant had appreciable day-night DO differences. Perhaps most surprising were the large swings in DO in the Ventura estuary (or lagoon). Here, the cause was not benthic nor floating algae but phytoplankton (the previous photo shows the green color of lagoon water). Further upriver, at Foster Park (VR06) the DO cycle was not as severe, even though the algal density appeared heavier here than at any other location. The diel variation was even less at the Matilija sites – although here too the algal density was appreciable (although not as dense as at VR06 and on the lower river). A reasonable question would be why?

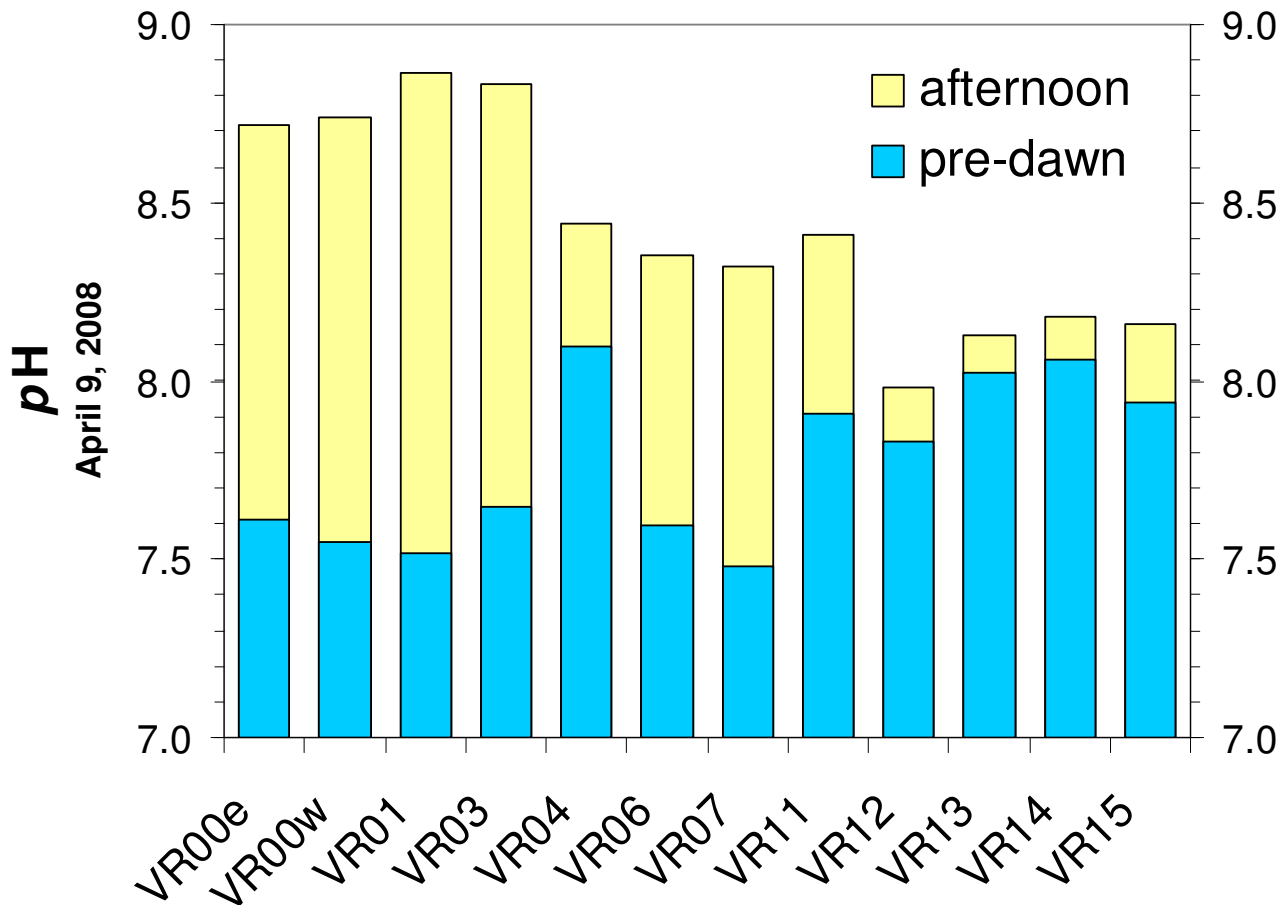
One possibility might be an increased rate of oxygen entrainment in the water. At night, higher turbulence (rapids, riffles) can replenish oxygen removed by algal respiration. As we proceed up the watershed hydraulic slopes become steeper and the ratio of pools (quiet sections) to riffles increases. However, this would mostly affect night-time DO differences, whereas the Matilija sites also show only moderate day-time super-saturation (105-109%). Deeper flows may also play a role – greater flows per unit width of stream would give benthic algae greater amounts of water on which to exert their influence, i.e., having a lower impact and producing less change. Greater flows per unit width would appear as either deeper water or higher stream velocities, or both. The Matilija tributaries and the upper river are constricted in steeper canyons and offer a narrower waterway with faster flows than the broad flood plains below Foster Park.

Another possibility may be conditions on the river reach above the sampling points. Conditions, such as DO and pH, measured at fixed location do not solely reflect changes that occur at that location, but some continuous process of change that extends some distance upstream. What distance, you may ask? Some currently *unknown* distance – dependent on river conditions, circumstance and the process in question. DO was measured at two specific times at each location, so we no way of knowing how it varied between those measurement points. But in 2003 similar measurements collected every three hours on the lower river showed that DO peaked around 2:30-3:30 PM, and pH even later. This is past the time of peak sunlight and, presumably, past the point of peak algal production and influence. And would seem to indicate that we were measuring changes that had occurred further up the river at some earlier point in time – changes that took time to manifest themselves at the point of actual measurement. If conditions on some upstream reach (extending an unknown distance) determine the measurements taken at a specific point, then a less pronounced DO cycle at the Matilija sampling points may simply indicate that stretches in these narrow canyons foster less algal growth than seen at the sampling point (i.e., a greater probability shading by riparian vegetation). (And in the special case of VR13, where the upstream reach ends at the dam, too short a reach to fully develop the algal signal.) Of course this doesn't preclude some combination of effects yielding a reduced diel cycle: spotty productivity in the upstream reach; deeper, faster flows; increased turbulence; and, probably most important, less algae to begin with.

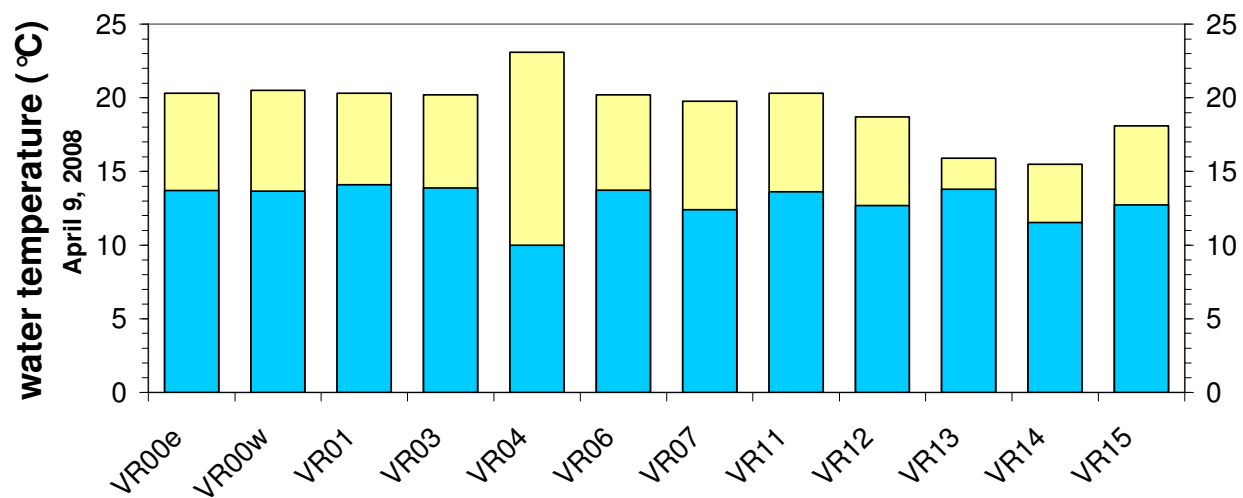
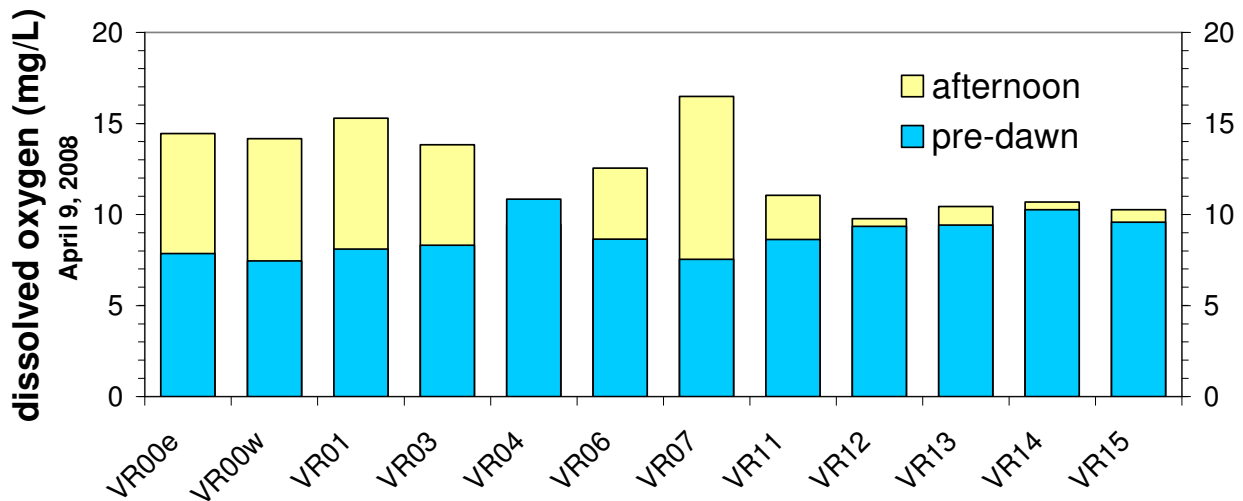
While at some locations (VR01, VR06) appear to be at the height of algal production and others at the beginning (VR14, VR15), yet others seem to have past their peak (VR07, and above the treatment plant; see photos on next sheet). At these locations decay appears to be well on its way; the algae is clumped as an organic mass and black in color. At these locations, the only green filaments were those in a high velocity, riffle environments. It's interesting to contemplate whether nutrient delivery, or lack thereof, is a cause – or an effect. Perhaps in the absence of turbulence growth becomes more than self-limiting.



April 9, 2008, from top to bottom and left to right: lower San Antonio, VR07; senescing algae, VR07; N.F. Matilija, VR14; Matilija Cr., VR13; upper Ventura River, below Matilija conjunction; just above the sewage treatment plant.



Carbon dioxide in water forms a mild acid (carbonic acid) and as it is removed by photosynthesis water becomes increasingly basic, i.e., the pH increases. This is similar to your drink tasting flat after it sits awhile and loses carbonation; loss of carbonation equals loss of acidity. So the diel pH cycle follows that of DO: pH, in the presence of algae, rises to an afternoon peak and then declines to a pre-dawn minimum. As with DO, all sites exhibited a noticeable pH cycle. While pH changes were greatest at VR01, they were appreciable at all locations below the Ojai Treatment Plant. It's interesting that the diel pH variation at lower San Antonio (VR07) was less pronounced than the DO variation. This would seem to suggest that San Antonio waters are more highly buffered than those of the river itself. The limited data available on ANC (alkalinity or acid neutralizing capacity) indicates that this is so. Large variations in pH are dangerous, a change of more than two points on the pH scale can kill many species of fish. The EPA and Regional Water Quality Control Boards regard a pH change of more than 0.5 as harmful (SWQCB-LA, 1994). Keep in mind that half a unit of pH is not a small thing, the scale is logarithmic and half a unit represents a 500 percent change. The largest change was at Main Street (VR01; 1.35 pH units), but all sites with the exception of VR04 and VR12-15 (0.11-0.22 units of change) had more than a half a unit of change. Typically, on the lower river (VR11-VR00) an increase of 5 mg/L in DO produced an increase of 1 pH unit. The Matilija creeks were slightly more sensitive, i.e., less highly buffered, a 1 unit increase for a 3 mg/L rise in DO.



The previous DO graph showed concentrations in units of percent of saturation. Here actual concentrations in mg/L are given, along with pre-dawn and afternoon temperatures, mainly to illustrate two points. First, that at none of the locations did DO drop below 7 mg/L – the minimum expectation of the mean concentration as stated in the Basin Plan (a single measurement can go as low as 5 mg/L). The lowest concentration found on this day was 7.48 mg/L (VR07). Second, the curious case of lower Canada Larga (VR04) where afternoon DO concentrations were actually lower than those found at dawn. The reason being water temperature. VR04 had both the lowest (10 °C or 50 °F) and highest (23 °C or 74 °F) temperatures recorded that day. The ability of water to retain oxygen is greatly reduced as temperatures rise. The true indication of algal growth at this site of very low and shallow flows lies in the diel pH cycle, not DO.

As the season advances we can expect flows to decrease and the diel cycles to intensify *if*, and it's a big if, algal production increases or remains the same. Typically, algal production will decrease from its current maximum on the lower river, but increase on the upper (where stream temperatures lag by about 4-5 °C). There may also be a second algal bloom in late summer or early fall. Should this occur, results from a repetition of this survey are likely to be more dire.