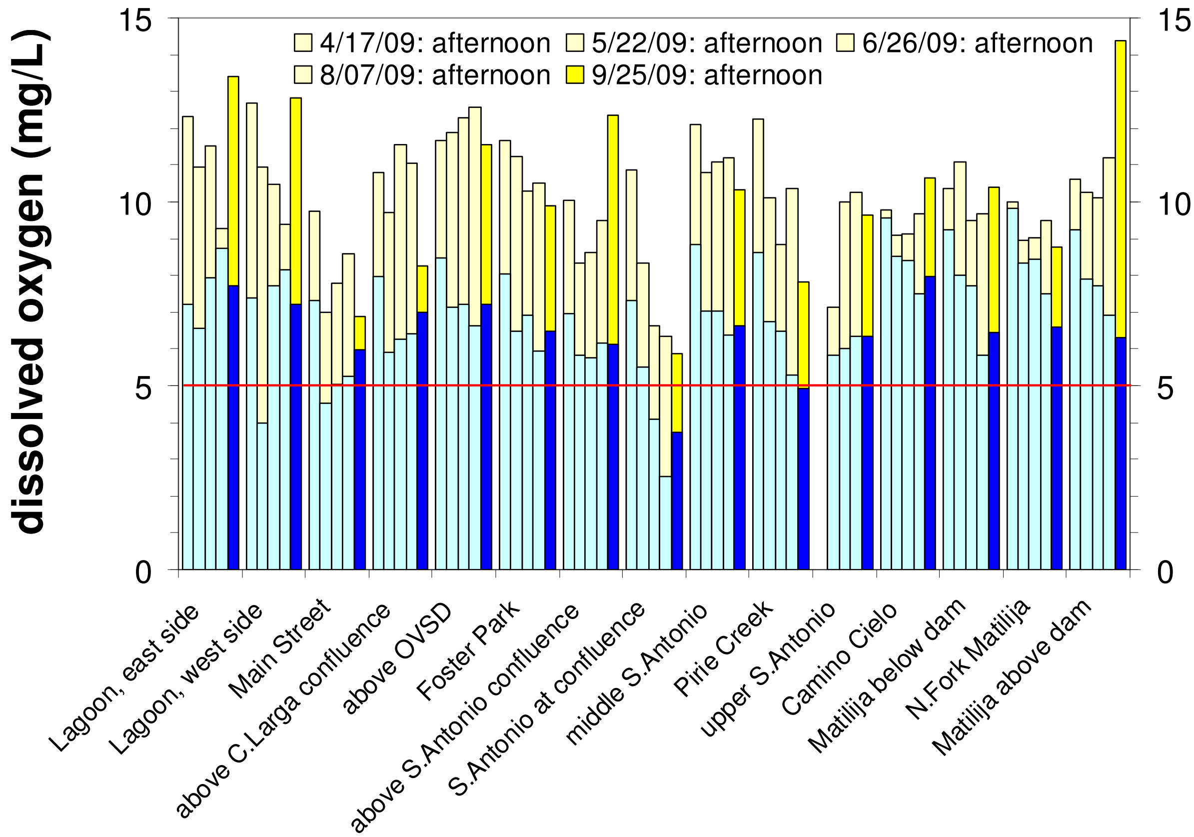
On September 25, 2009, Santa Barbara Channelkeeper completed a fifth – *and final* – round of 2009 diel measurements of dissolved oxygen (DO), water temperature and *p*H on the Ventura River and its tributaries. As before, pre-dawn measurements were made between 4:30 to 6:30 AM, afternoon measurements between 1:30 and 3:30 PM. The dissolved oxygen values recorded on this date, and during previous 2009 sampling events, are displayed on the following graph (in mg/L, i.e., ppm). Fifteen locations, including 2 on the lagoon, were sampled in September.



The lowest DO value recorded on August 7th was 3.72 mg/L on lower San Antonio Creek, just before its confluence with the Ventura River. Since San Antonio Creek on the other side of Hwy 33 (about a half mile above this confluence) has been dry for months, and since the confluence reach is now only a series of disconnected puddles, this value is probably without significance. The only other location below the 5 mg/L Ventura basin plan limit (shown as a red line on the graph) was Pirie Creek at 4.9 mg/L. Main Street at 6.0 mg/L was the next lowest, but this reading represents an increase over last month's 5.25 (itself up from June's 5.04).

Delta-DO values, defined as the difference between the maximum and minimum daily dissolved oxygen concentrations (or in Channelkeeper's case, the difference between mid-afternoon and pre-dawn concentrations, the approximate times when these extremes normally occur) are shown in the upper panel of Figure 1. Delta-DO for April, May, June and August 2009 are contrasted with values for the same months in 2008.

Delta-DO values below the Waste Water Treatment Plant (WWTP) continue to remain much lower than last year, indeed, have dropped to the lowest seen in either 2008 or 2009; elsewhere they present a mixed picture – some months higher, some lower. In general, September delta-DO values

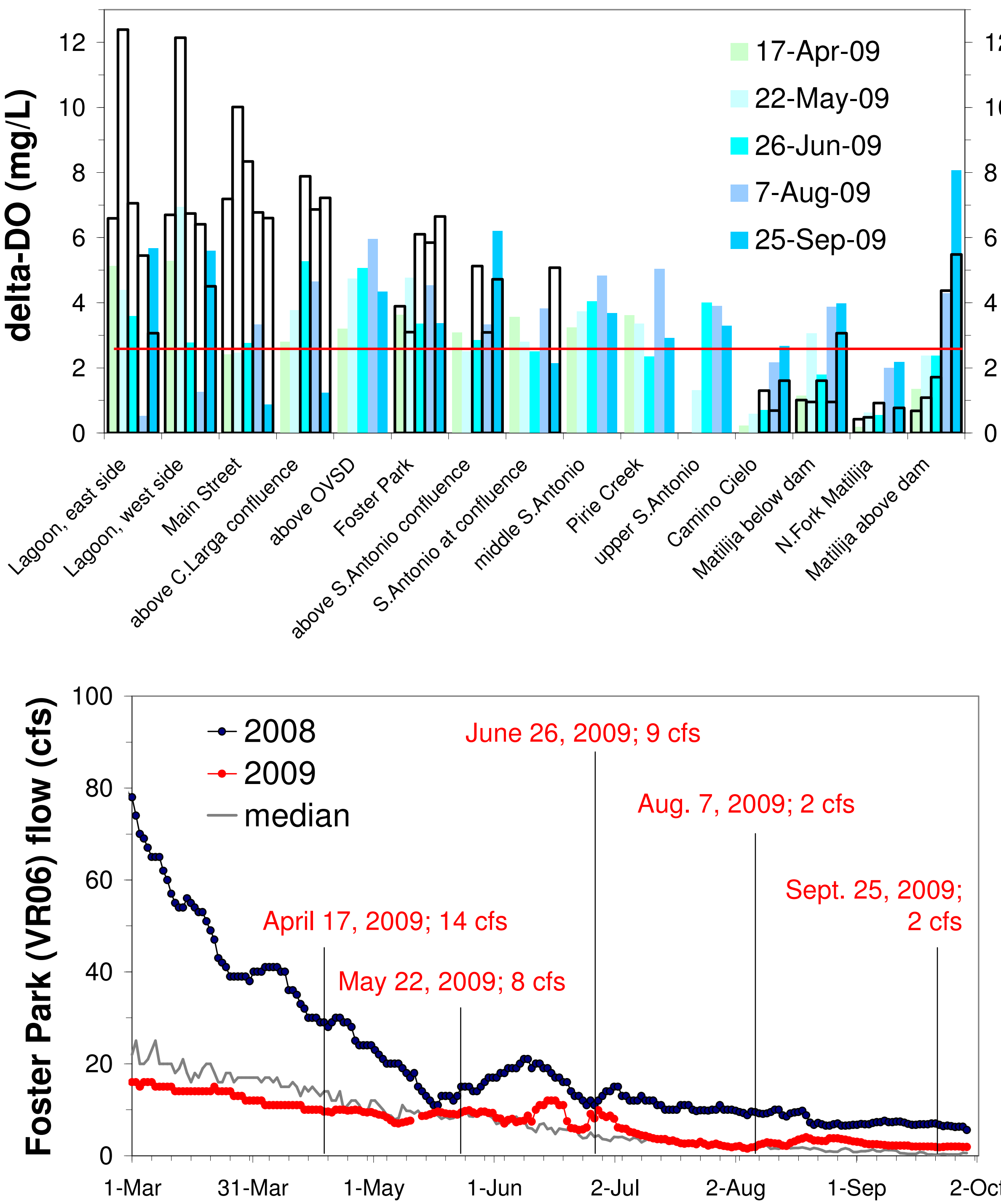


Figure 1. (upper) Delta-DO values for April through September 2009 are contrasted with data from similar months in 2008. Last year's data are shown as "white" background bars where the values were higher, as black outlines (i.e., transparent bars) when lower. The red line at 2.5 mg/L represents the delta-DO equivalent of a maximum oxygen deficit limit of 1.25 mg/L used by the Central Coast Regional Water Board. (lower) Average daily flows at Foster Park, since March 1, for 2009 (red) and 2008 (black); this year's diel sampling dates (in red) and the long-term average daily median flow are also shown. This year's flow, which had been nicely tracking the long-term median, is now appreciably above it (2 vs. 0.3 cfs).

Figure 2. Looking east along the RR bridge over the lagoon (VR00): the upper photo from September 25, the lower from August 8. Delta-DO appreciably increased in September over the August value (5.7 vs. 0.5 mg/L) even though there has been no visual change in conditions. A recent look at high quality sonde data from Goleta Slough has convinced me that I've been too cavalier about what might be happening in the slough. Tidal fluctuation as well as how "new" the most recent tidal inflow happens to be appear to exert a sizable influence on oxygen levels. As these photos illustrate, tidal differences are usually appreciable and that mid-afternoon DO levels were measured near high tide in August and near low tide in September probably accounts for a major part of the delta-DO differences.

represent a decrease from August at Foster Park and above the treatment plant, and throughout San Antonio Creek. This is not unexpected; cooler temperatures and shorter days could alone be responsible for the decrease. What *is* unexpected is a general increase in the upper basin where September delta-DO values are at the highest levels seen this year – and appreciably higher than at any time in 2008. A similar situation has developed above the San Antonio confluence.

The principal reason seems to be low flow. Flows continue to decrease and late blooming species like *Mougeotia and Spirogyra* (and let's not forget diatoms) that do well in quiescent waters and low nutrient environments have delivered kind of a double whammy. Again, delta-DO is the product of both the amount of algae in a reach and the amount of water the algae influence; delta-DO is directly proportional algae to biomass and inversely proportional to flow. Thus decreasing flows magnify the impact of whatever algae are still doing well this late in the season.

In June I reported that the lagoon had returned to the green soup-like state of April, dominated once again by phytoplankton. This situation continued into August when highly oxygenated tidal inflows appear to have accounted for the very low delta-DO values measured (minimum pre-dawn DO values were 8.14 and 8.75 mg/L). Much to my surprise September delta-DO was very much higher than in August even though everything looked very much the same (5.7 vs. 0.5 mg/L, although minimum values remained within an acceptable range of 7.2-7.7 mg/L). It appears I've been too sanguine about what might be happening in the lagoon, not to mention not thinking nearly hard enough.

Thanks to the courtesy of Lisa Stratton at UCSB, I've been able to take a good look at some high quality sonde data from Goleta Slough, and it's been eye-opening to say the least. Water levels and water temperature, things that I have not paid all that much attention to in the past, appear to highly influence algal response, as does how recent has been the most recent arrival of highly oxygenated fresh saltwater from the channel. It now seems obvious that a tidal fluctuation often in excess of 3 feet should have a major impact – if for no other reason than the amount of water algae might work their magic upon has been drastically decreased, not to mention what might be happening with the amount of algae, or their activity, or their growth and development. But sad to say, I've been quite oblivious. Given no other available data, that the peak DO measurement in September was made near low tide while that of August was taken near high tide would seem to be enough to account for differences in the monthly measurements (Figure 2).

As discussed in previous diel reports, Chl-*a* density data collected in last year's UCSB-TMDL algal study and Channelkeeper's near contemporaneous delta-DO measurements, along with Ventura County, USGS and Channelkeeper flow records, allowed the development of a model derived by regressing delta-DO on Chl-*a* and Q. The model, displayed as a graph in Figure 3, features lines of equal Chl-*a* densities (red numbers representing density in mg/m^2), and furnishes an estimate of Chl-*a* after entering values of flow (in cfs on the x-axis) and delta-DO (in mg/L on the y-axis). In Figure 3 my latest version adds September flow and delta-DO values for 2008 (September 12^{th}) and 2009. This year's data is shown in shades of blue, last year's in blander colors; Channelkeeper site numbers are shown only for September 25, 2009 data.

The UCSB Report recommended Chl-*a* standards of: (1) less than 50 mg/m^2 defining "unimpaired" reaches, (2) greater than 200 mg/m^2 considered " impaired"; with (3) anything falling in-between requiring further study or monitoring. Alternately, 150 mg/m^2 was offered as a single limit. Presumably, these standards or something similar will be adopted in the eventual TMDL. Up until September no location sampled in 2009 could be classified as unequivocally "impaired," and only a few had fallen into the "above 50" category where they might be regarded as contenders.

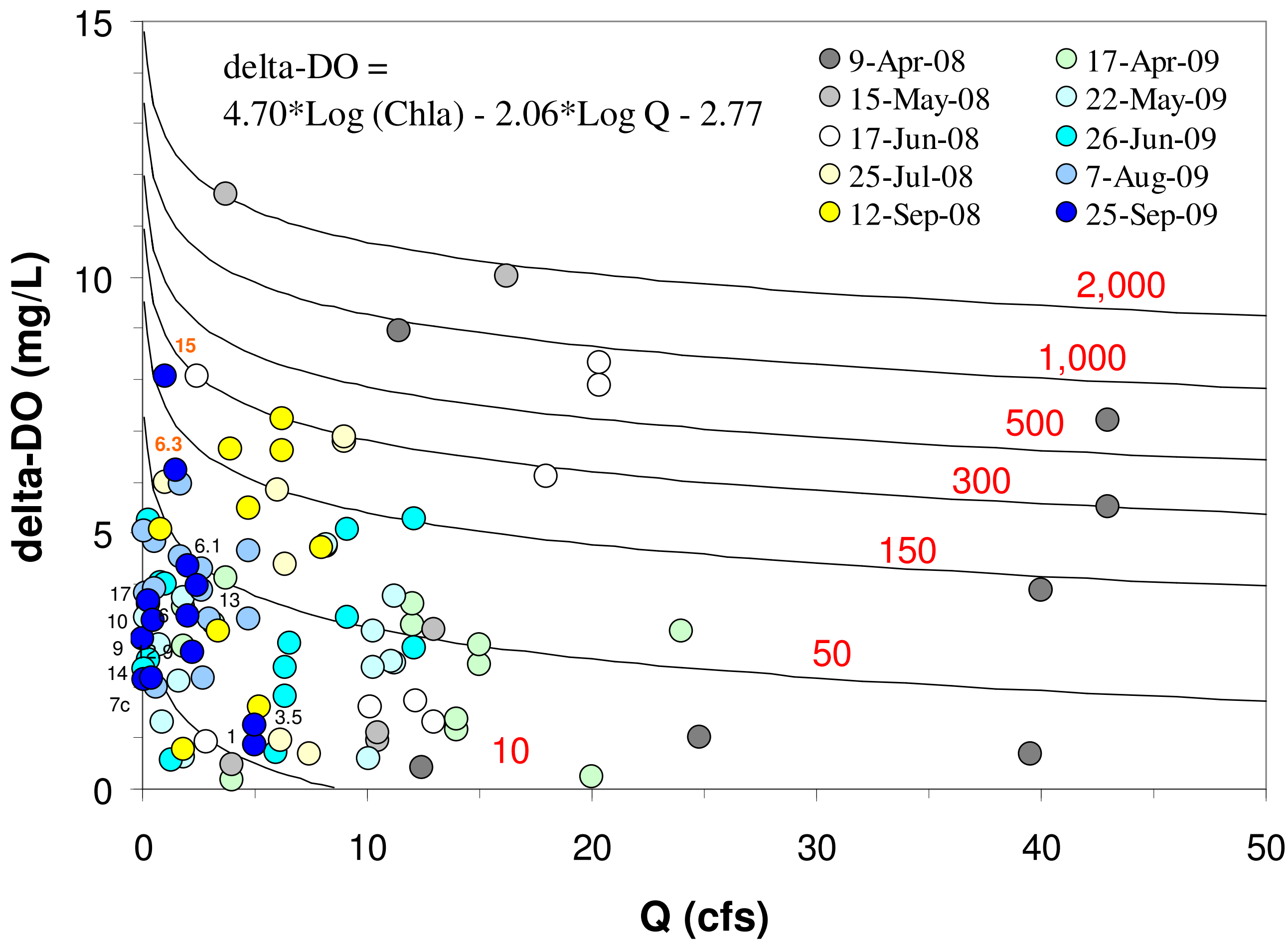
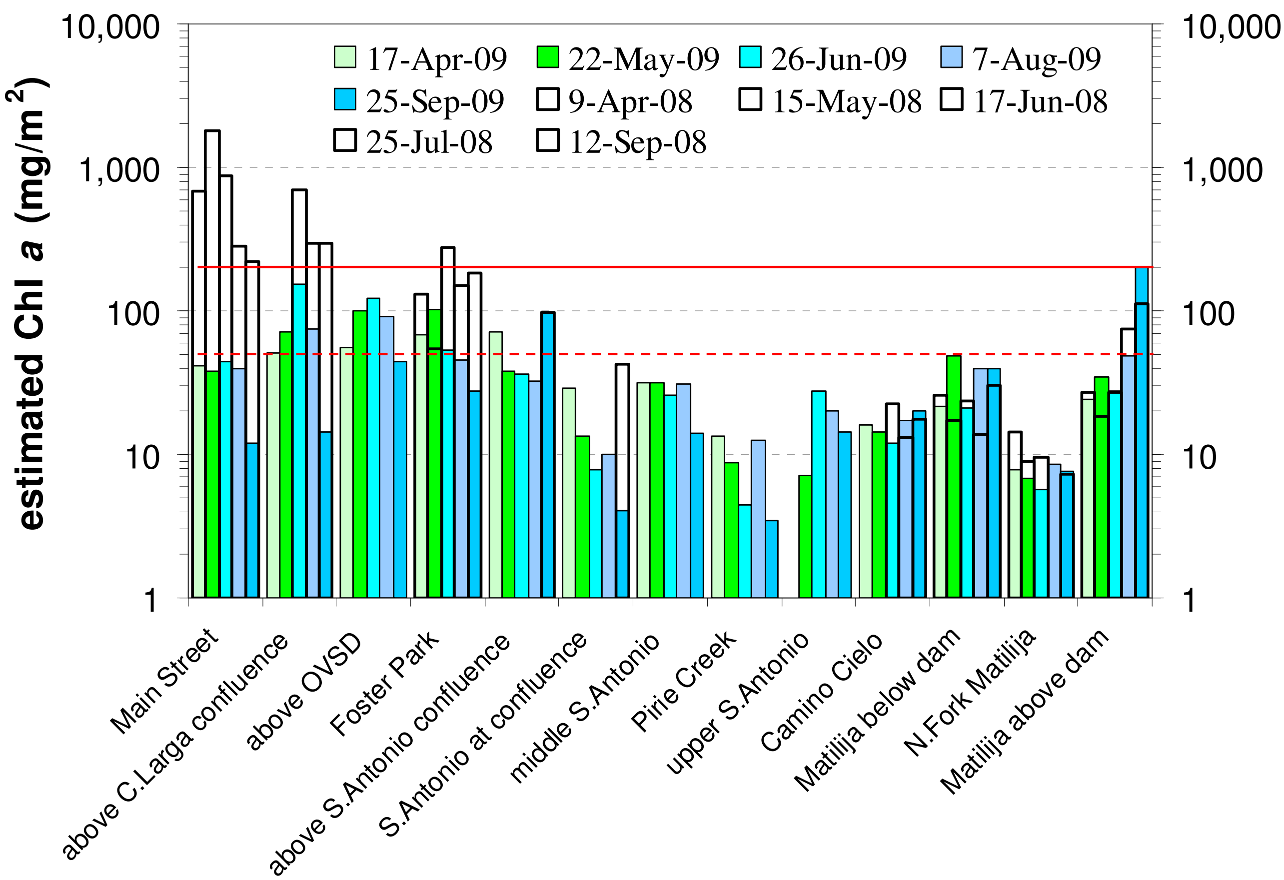


Figure 3. The chart shows the revised graphical model developed using data from the UCSB-TMDL study, Ventura data collected by Julie Simpson and myself in 2003, and 2008 Calleguas Creek data collected by Diana Engle. The regression relationship used in the model is shown on the graph ($p < 0.001$, r-squared = 0.87). Although the regression equation shows delta-DO as the dependent variable (required to plot the graph in this fashion, with Q and delta-DO on the axis', and modeled Chl-*a* as lines labeled in red with density in mg/m^2) the model was derived using Chl-*a* as the dependent variable. The chart shows 2009 diel sampling data, collected by Channelkeeper, in shades of blue, with data collected during the corresponding months in 2008 in shades of yellow and grey. Channelkeeper site codes are shown only for the September 25, 2009 data. Unlike 2008, which exhibited a wide range of algal conditions and Chl-*a* values, 2009 data are clustered in the lower left-hand corner. Until September no sampled 2009 locations approached the 150-200 mg/m^2 recommended lower-limit of undeniable impairment; however, two locations (marked in red, Matilija Creek above the dam (#15) at 203 and the San Antonio confluence (#6.3) at 98) have now either exceeded or are approaching it. However, aside from these sites, the general trend by the end of September had been a decrease in algal density (lower Chl-*a*) and a diminishing diel oxygen cycle (decreasing delta-DO). With the advent of lower temperatures and shorter days conditions at even these sites will probably begin to improve, i.e., we've already seen the worst.

Figure 4. Matilija Creek above the dam (VR15): This site was the big September surprise: algal density is estimated at 203 mg/m^2 – above the recommended 150 UCSB limit – and DO varied from a high of 14.4 to a low of 6.3 mg/L. Very low flows would appear to be the major part of the problem. TN and TP at this location average 0.18 and 0.019, respectively – both well below the proposed limits.

However, with continually decreasing flows the September situation on Matilija Creek (above the dam) took a decided turn for the worse. Estimated Chl-*a* at this location reached 203 mg/m^2 (Figure 4), making it, ironically, the most algal impacted site during 2009. Ironically, because nutrient concentrations at this site come nowhere near the UCSB recommended limits designed to divide unimpaired from potentially impaired reaches (0.40 mg/L for total nitrogen (TN); 0.025 mg/L for total phosphorus (TP)); average annual TN and TP concentrations for this Matilija sampling location are 0.18 and 0.019 mg/L, respectively.

Since the graph in Figure 3 doesn't adequately show the progression of site by site algal growth over the course of the season, I've displayed estimated Chl-*a* densities using a different format in the next graph. 2009 values are shown as blue or green bars (based on the month) while estimated Chl-*a* densities for the corresponding months in 2008 are shown as "transparent" foreground bars (i.e., they appear as a "white" bar in the back when 2009 values were higher, as a horizontal line through a colored bar when lower).



Chl-a densities in 2009 on the lower Ventura River and on lower San Antonio Creek are roughly an order to an order-and-a-half magnitude lower than in 2008 (order-of-magnitude = 10-times, an order-and-a-half = 50-times). Elsewhere the picture is mixed: some locations, like Foster Park, are generally lower than in 2008, while those in the upper basin are quite similar and, at times, higher (most of the San Antonio Creek sites have no track record having been un-sampled in 2008). Another interesting difference between the lower river locations and those in the upper basin is the trend towards peak Chl-*a* at the beginning of the season followed by a continual decline for the former, while the latter show a gradual increase, reaching maximum Chl-*a* at the end of the algal season.

This is probably best explained by differences in the primary suspects: *Cladophora*, which does well in high nutrient, high flow conditions, dominates at lower river locations, while *Spirogyra* and *Mougeotia* which do better in quiescent waters, and have a tolerance for low nutrient conditions, exert great influence in the upper basin. Although the upper basin also has substantial blooms of *Cladophora* these tend to occur very early in the season and are usually short lived, occasioned by high, fast-moving, flows of early spring and a higher than normal, post-winter, flush of nutrients from recent recharge – fortunately, these are exactly the flow conditions that minimize the impact of algal growth on parameters such as dissolved oxygen and *p*H. Unfortunately, as the season wears on conditions for the growth of *Spirogyra* and *Mougeotia* continue to improve as flows decrease and the impact of what is usually considerably less algae becomes magnified. The flow decrease in the upper basin from the end of March to the end of September is usually on the order of 75-80 % during drier years.

The graph also includes red horizontal lines to mark the UCSB algal density criteria (200 and 50 mg/m^2). I've also revised, by including September data, the new graph I added last month to try and clarify the relationship between Chl-*a* and delta-DO (Figure 5). As I seem to endlessly (and probably aggravatingly) keep mentioning, the connection between them is flow: delta-DO being directly proportional to Chl-*a*, but inversely proportional to flow. Differences between the two values, e.g., delta-DO increasing as the months wear on while Chl-a decreases, signify the influence of flow; in this example greatly decreasing flows increasing delta-DO in spite of a decrease in algal density.

Again, I'll forgo any discussion of water temperature. Or of *p*H. The emplaced Channelkeeper temperature loggers in the upper basin (sites VR12.9 to 15 and above) have been retrieved as of the beginning of this month, and after some time for analysis we'll devote a special report to the results. As might be expected, water temperatures throughout the watershed began to decrease in September with the sole exception of the San Antonio confluence. Here extremely low and shallow flows were the cause of this suprising result. Needless to say, this does not bode well for those trout still hanging out at the confluence pool. Those guys have not had an easy time of it, what with poaching throughout the summer, San Antonio running dry relatively early in the season, groundwater inflows into the upstream Ventura reach slowing to a warm trickle and, as the photos will show, a serious algal situation in the pool itself as well as below it (a place we, unfortunately, never even thought of sampling).

And speaking of photos, they make up the remainder of this report. Last month I tried to contrast what things looked like in August with conditions back in April (or whatever date the earliest comparative photo was taken). This month I'm trying to showcase some of the sites we rarely show pictures of, either because they usually have no outstanding or special algal problems or are just downright ugly. I've also included photos from some of the special cases mentioned in the preceding discussions.

As usual, photos taken on diel sampling days (and on other Channelkeeper sampling days in 2008 and 2009) can be downloaded at:
http://sbc.lternet.edu/~leydecke/Al's_stuff/Recent%20Stream-Team%20Photos/

Posted PDF copies of all my previous Ventura Nutrient TMDL reports can be found at:
http://sbc.lternet.edu/~leydecke/Al's_stuff/Ventura%20Nutrient%20TMDL/My%20PDF%20files%20on%20algae%20&%20nutrients/

For additional information or questions, or comments and opinions, or even hate mail, please feel free to email me at: al.leydecker@cox.net

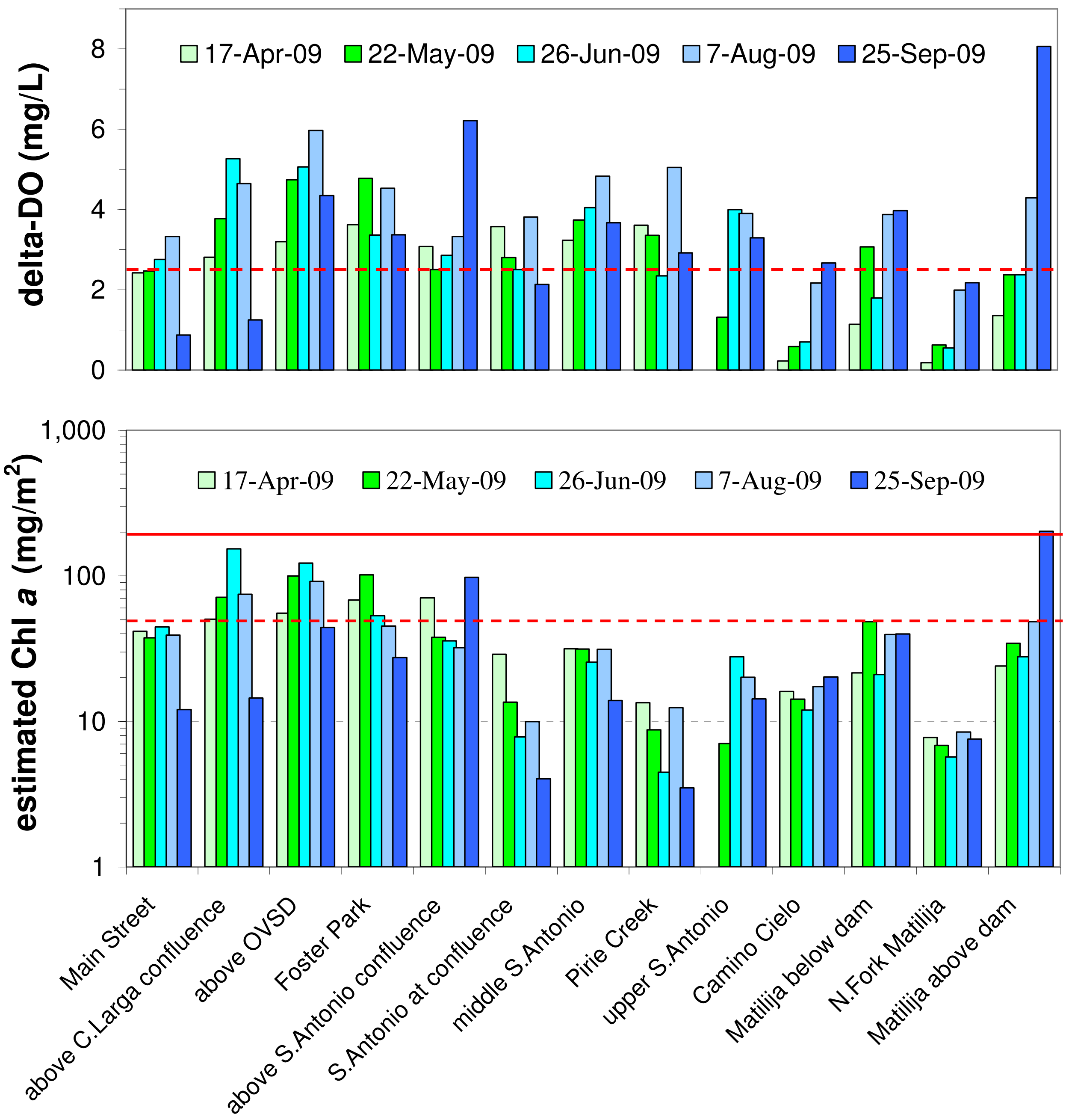


Figure 5. Delta-DO values for April through September 2009 are shown in the upper panel while estimated algal densities in mg of Chl-*a* per m^2 are shown in the lower. The red line at delta-DO = 2.5 mg/L represents the delta-DO equivalent of a maximum oxygen deficit limit of 1.25 mg/L used by the Central Coast Regional Water Board; the UCSB recommended Chl-*a* criteria of < 50 (unimpaired) and >200 mg/m^2 (definitely impaired) are shown as red lines in the lower graph. Since delta-DO is directly proportional to Chl-*a* and inversely proportional to flow, differences between the two graphs relate directly to changes in flow, e.g., increasing delta-DO values as the summer progressed on middle San Antonio Creek had to be caused by diminishing flows since Chl-*a* densities remained relatively constant (and the decrease in September delta-DO, in spite of still decreasing flows, was due to a very large decrease in Chl-*a*; keep in mind that very great differences in numbers may only produce only small changes in appearance on a log scale).

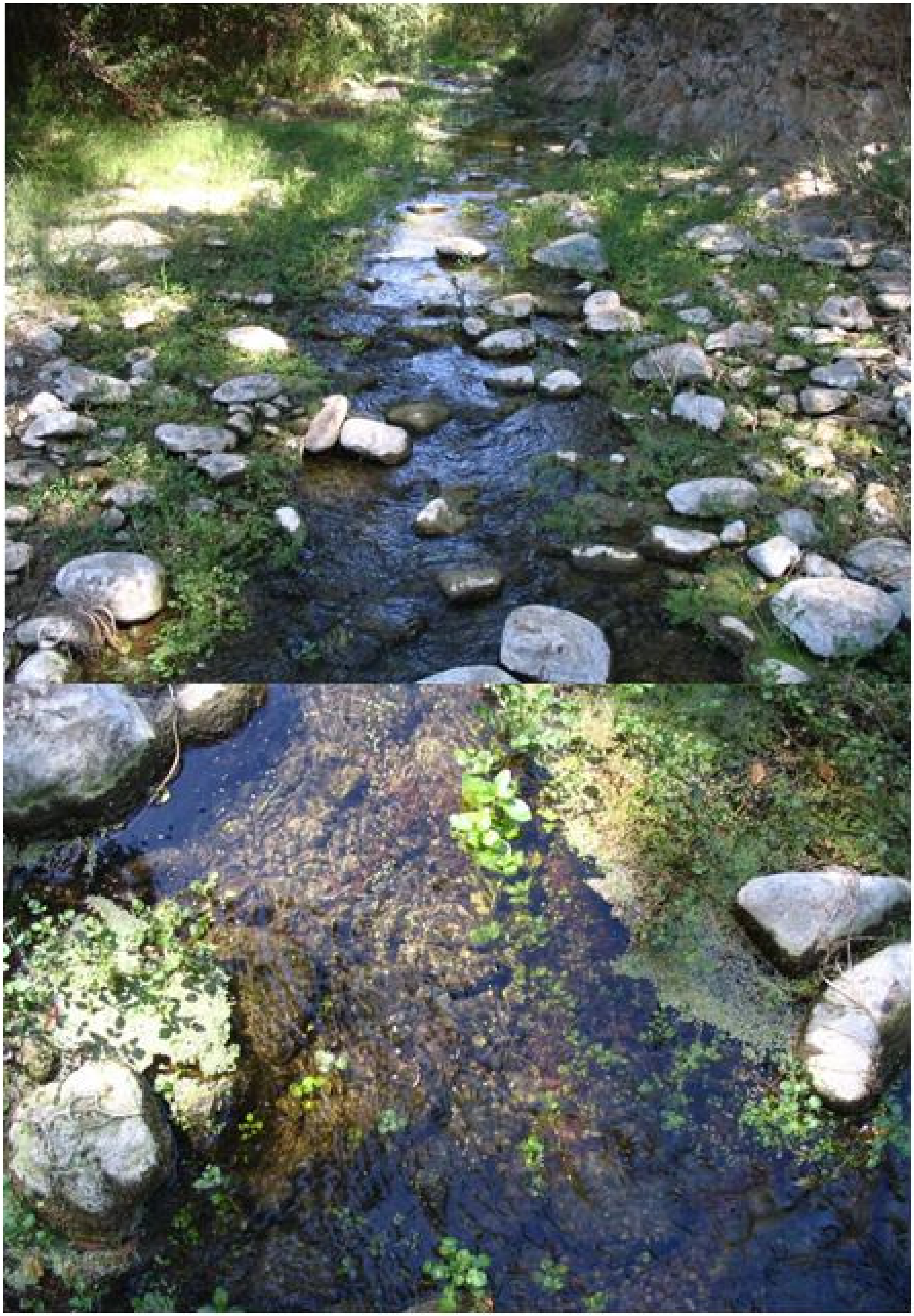


Figure 6. Pirie Creek (VR09): looking upstream from the Creek Road bridge. Pirie is a predominately urban (Ojai) stream with high TN (1.9 mg/L) and high TP (0.075 mg/L). However, a relative lack of sunlight usually keeps algal growth at a minimum.

Figure 7. Upper San Antonio Creek (VR10): looking upstream (top) and down (bottom) below the Skunk Ranch Rd. crossing. This stream is predominately agricultural with the highest TN (4.9 mg/L) in the Ventura basin but low TP (0.025 mg/L); as with Pirie, shade greatly retards algal growth.

Figure 8. Middle San Antonio Creek (VR17): looking downstream and directly below the Rancho Dos bridge. This reach is approximately 1.8 miles below VR09 & 10. TN levels are lower here than on the upper San Antonio, but open topography and lack of riparian shade yield extravagant algal growth.

Figure 9. Looking upstream from just above the San Antonio confluence (VR06.3): Very low flows are producing high delta-DO (6.2 mg/L) with relatively low Chl-*a* (98 mg/m²).

Figure 10. The interesting development at the San Antonio confluence however, is not above but below – downstream of the pool harboring all those young trout. This reach has become choked with algae.

Figure 11. And the confluence pool itself is not looking all that good. The lower photo shows how little water from above is now flowing into the pool (San Antonio Creek itself has been dry for months).

Figure 11. Camino Cielo (VR12.9): Appreciable algal growth appears to be occurring at this location (about ¼ mile below the N.F. and Matilija confluence). However, estimated algal density is still low (20 mg/m^2) and delta-DO remains a moderate 2.7 mg/L.