DSC-1

Written Introduction

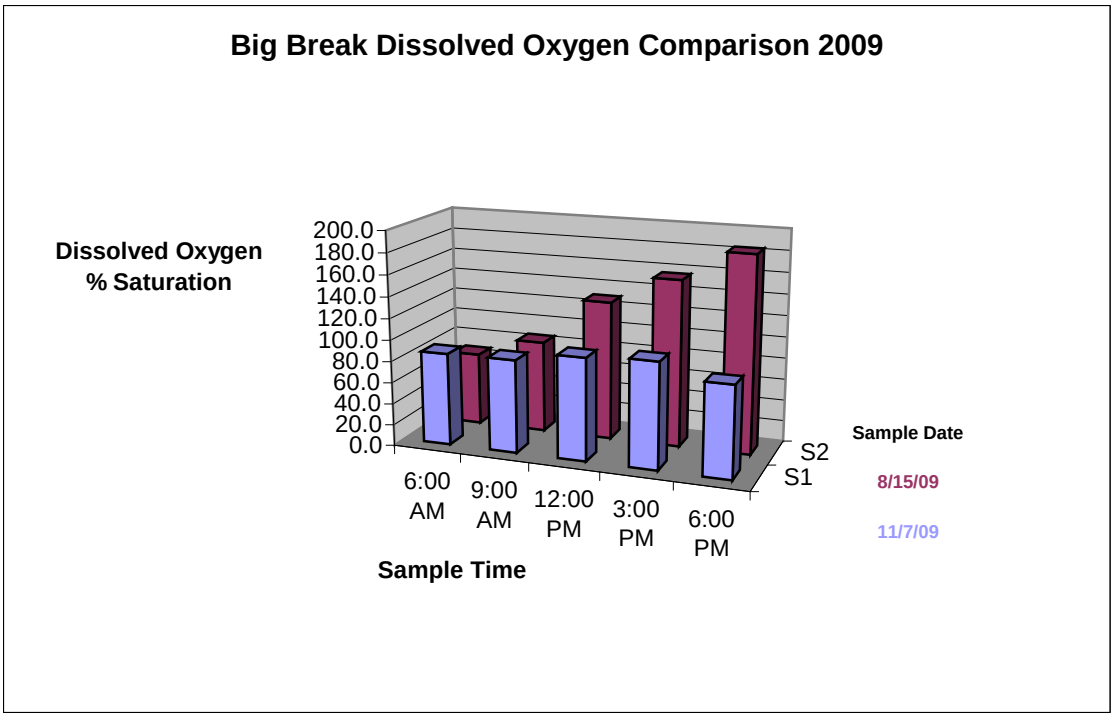
The following discussion and exhibits are the result of more than a half-dozen years of observation and testing in the Delta, as well as the Marsh Creek watershed which feeds into the Delta. The work is original and thus requires explanation of the reasons for its undertaking, the conditions under which the work was carried out, the quality assurance procedures followed, and the identification and qualifications of the investigators.

The findings to date are, we believe, symptomatic of a serious condition, highly debilitating to all aquatic life in the Delta. The condition occurs only in late summer, however, and the symptoms must be observed over extended periods of time to be appreciated and understood. This is likely why it has not been studied before and acted upon. The condition we speak of is called hyper-eutrophication, shown visually in Figure 1.

Figure 1, Big Break looking north from Observation Pier, 8/10/2009

The scene on the previous page is common to many who fish, travel, or seek other recreation on the Delta. While the weeds are usually thought-of as a nuisance, what the weeds, in cooperation with long hours of sunlight, gentle mixing provided by the tides, and driven by high concentrations of nutrients, alter the aquatic environment making it intolerable for almost all insect and fish species living there.

Without going into detail at this point, the two parameters of water chemistry that are driven outside of livable conditions are dissolved oxygen and pH. Changes in dissolved oxygen concentrations over two 24-hr periods are shown in Figure 2.



The purple bars are for a series of tests done in August 2009, when the days were still long and there was prolific weed growth. In this case, a more than three to one change in dissolved oxygen took place. Later in the year, when days are shorter as sown with the blue bars, dissolved oxygen in the water is more or less constant. Rapid changes in dissolved oxygen as shown, while not necessarily known to be lethal, are known to cause avoidance behavior, reduced growth, and increased susceptibility to predation for many species (US EPA, 1986). While much of the available research has focused upon low dissolved oxygen, periodic spikes in dissolved oxygen, well above the saturation

concentration limit in water, can cause the formation of bubbles in the gills of fish and aquatic invertebrates (USGS, Report 2008-5201). This condition in the water also can result in spikes in pH that further stress organisms already impacted by dissolved oxygen. During the same series of tests we ran in August, 2009, pH in the Big Break waters ranged from as low as 7.0 during periods of darkness to as high as 9.4 in the late afternoon. USEPA has determined that a pH range of 6.0 to 9.0 is protective to most marine life (EPA, 1976, 1986). At levels above 9.0, studies have shown damage to the gills, skin and eyes of many species (Weibe, 1931, AFS 1979, Alabaster and Lloyd 1980). When combined with super-saturation levels of dissolved oxygen, the impact on fish and aquatic insects can be substantial. Based upon observations of weed growth, these damaging water quality conditions should be anticipated for one to two months each year in the Delta.

All this being said, our findings to date have been limited in both duration and geographical reach. We are working on both of these issues at the time of this writing. More of the Delta, including reaches of both the Sacramento and San Joaquin rivers as well as several identified sources of nitrates will be studied during spring and summer of 2010. Time and resources permitting, these locations will be evaluated two or three times before the end of 2010. Both dissolved oxygen and pH effects can be attributed to plant photosynthesis and respiration, essentially driven by unlimited concentrations of nitrates in the Delta waters tested so far. During the tests we did in the Delta in August 2009, nitrate concentrations were in the range of 25 mg/l to 35 mg/l measured as NO_3^-. At present, EPA does not publish numerical criteria for maximum nitrate concentrations in natural waters. EPA's Canadian equivalent, however, recommends maximum concentrations of nitrates to 13mg/l to avoid outright toxicity and 4 mg/l to avoid eutrophication. These Canadian guidelines are a factor of two to six smaller than the observations we have made in the Delta. At this time in the US, unfortunately, do not have regulatory guidance to address the observed problem, just the observation itself. Nonetheless, we feel that inclusion of study and eventual regulation of the impacts of nutrients in the Delta will be one of the tools necessary to improving Delta ecological health. In addition, the inclusion of nitrate concentrations as a figure of merit to judge the

progress of healing the Delta will be justified. If the impact of nutrients in the Delta is as widespread as likely, no reasonable amount of increases in flow out of the Delta alone will be successful. Improving conditions, however, will require additional strategies including reductions in nutrient discharges from wastewater treatment plants, reductions in the amount and nutrient concentrations in agriculture drain water, and improvement in the quality of urban runoff.