DSC - 2
Delta Flow Criteria
Eutrophication Studies

There are many factors which can lead to stresses on the anadromous and pelagic fish in the Delta. Our exhibits, however, will be limited to those illustrating hyper-eutrophication and the sources of nutrients and particulates that drive that phenomenon. The discussion is divided into two parts. The first describes observations and data from the Big Break area of the Delta. The strategy here is to link visual observations to analytical data. Since this work has not been published widely, all data are included.

The second part of this presentation describes eutrophication of a storm water pond that was subject to the same type of water chemistry changes and over the same general time period as our studies on the Delta.

Figure 1 shows an area near where the pier has been built in the East Bay Regional Park. The park is called the Big Break Regional Shoreline and is located off the end of Big Break Road in Oakley, CA

Figure 1, Image of Big Break Regional Shoreline, September, 2009

We will start with a display of photos of submerged aquatic weeds in the area immediately off the pier in 2004, shown in Figure 2.

Figure 2, View of Weeds off Big Break Pier, September 2004

You can see in this photo a large flock of pelicans, actively feeding. Weed growth, while abundant, does not cover the surface, nor are there any obvious gas bubbles present. Unfortunately, no analytical data is available for that time.

Three years later, in September of 2007, aquatic weeds were present, but again not in great profusion, as shown in Figure 3. Nitrate in the water at this location was approximately 8 mg/l measured as NO^{3-}. While no bubbles were observed in the water during this sampling event, dissolved oxygen at the surface had risen to approximately 100% of saturation by 9:30 in the morning. Obviously something was happening to the water chemistry. Soon after these photos and data were taken, it clouded over and started to rain. Further data on water quality at that time are given in Table 1.

Figure 3, View of Big Break Pier, September 20, 2007

Figure 4, View from Big Break Pier, August 10, 2009

Things had changed substantially by the summer of 2009, as shown in Figure 4. Weed growth was intense and widespread. In addition, by late afternoon each day, bubbles could be observed in the weed beds, as shown closer up in Figure 5.

Figure 5, Close-up View of Weeds, 8/15/09

We had clues that something serious was happening from parallel work being conducted in Marsh Creek, which discharges into the eastern end of Big Break. Sampling work carried out on August 15, 2009 at the Big Breaks site showed huge variations in dissolved oxygen and pH from day to night, shown in Table 2. With oxygen levels swinging from 6mg/l up to 15 mg/l (well above saturation) and pH rising to above 9.0, serious damage certainly can be expected for many aquatic organisms.

Towards the end of the summer of 2009, a brief survey of local waters was done to start evaluating the source(s) and extent of nutrients entering the Delta. Those data are shown in Table 3. Nitrates in concentrations high enough to cause eutrophication were found in all samples. Note, in particular, the sample taken from Marsh Creek, just downstream from a treated municipal wastewater discharge and a large irrigation return discharge. In this sample, nitrates were over 80 mg/l. These levels are known to be toxic to a large range of organisms.

The impact of severe eutrophication can be seen even more vividly in Figure 6, taken at the mouth of Marsh Creek in September of 2009. Weed growth at that time was so thick that it was impossible to paddle a kayak through it.

Figure 6, Mouth of Marsh Creek, 9/11/09

Table 1, Sample Analysis Data, 9/22/07

Site	Big Break	Big Break	Big Break
Location	Near Shore	100 m Out	300 m Out
Time:	8:15 AM	9:00 AM	9:30 AM
Temp, oC, field	18.7	19.0	19.0
Conductivity, us, Lab, Vernier	1660.0	1554.0	1637.0
pH, site, compact meter	7.1	6.9	6.7
Alkalinity, mg/L	75.0	88.0	75.0
Water Depth, m	0.9	2.1	1.7
D.O. mg/L, Surface, Oakton Meter	7.1	8.9	9.3
D.O. mg/L, 0.2m from bottom, Oakton Meter	6.1	8.1	7.7
Turbidity, JTU, Kit	5.0	5.0	5.0
Nitrate, Ion, Vernier Probe, mg/L	8.2	7.2	8.8
Ammonia, mg/L, Test Kit	0.0	0.0	0.0
Phosphate, mg/L, Test Kit	0.2	0.2	0.2
Ca Hardness, mg/L, Test Kit	200.0	180.0	180.0
Total Hardness, mg/L, Test Kit	220.0	200.0	200.0
Chloride, mg/L, Mohr Titration	335.0	362.0	355.0
Sulfide, mg/L, Test Kit	0.0	0.0	0.0

Table 2

August 15/16, 2009
Big Break
D.O. Respiration Test

Sample Point GPS Coord.	Location Description	Time	Temp ^0C	D.O. Sat mg/l	Meas. D.O. mg/l	D.O % Sat	pH	Alk mg/l	Nitrate mg/l NO_3^-	Turbidity NTU	Cond Umho/cm
N 38° 00.754'	Park Pier	3:00 PM	26.0	8.1	12.7	156.8	9.1	55.0	34.6	8.3	1160
W 121° 43.693'		6:00 PM	24.5	8.3	15.3	184.3	9.4	55.0	31.2	5.6	1010
		9:00 PM	23.3	8.5	13.6	160.0	7.0	70.0	31.2	10.0	1030
		12:00 AM	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
		3:00 AM	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
		6:00 AM	21.6	8.8	6.0	68.2	N/S	N/S	N/S	N/S	N/S
		9:00 AM	22.7	8.6	7.4	86.0	8.3	65.0	24.0	79 *	1130
		12:00 PM	24.3	8.3	10.8	130.1	8.8	60.0	29.0	2.3	1010

Table 2, continued

Sample Point GPS Coord.	Location Description	Time	Temp ^{0}C	D.O. Sat mg/l	Meas. D.O. mg/l	D.O % Sat	pH	Alk mg/l	Nitrate mg/l	Turbidity NTU	Cond Umho/cm
N 38^o 01.013'	Islands	3:00 PM	28.0	7.8	12.7	162.8	9.1	55.0	32.8	22.2	1040
W 121^o 43.645'	north of Pier	6:00 PM	26.9	8.0	13.7	171.3	9.3	55.0	33.2	12.0	900
		9:00 PM	23.8	8.4	6.4	76.2	7.9	55.0	31.2	4.7	1030
		12:00 AM	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
		3:00 AM	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
		6:00 AM	23.4	8.5	9.0	105.9	8.0	65.0	29.0	5.0	1080
		9:00 AM	23.9	8.4	10.2	121.4	8.5	60.0	24.0	11.5	1083
		12:00 PM	26.4	8.1	13.3	164.2	9.3	75.0	26.5	2.5	960

Table 2, Continued

Sample Point GPS Coord.	Location Description	Time	Temp ^{0}C	D.O. Sat mg/l	Meas. D.O. mg/l	D.O % Sat	pH	Alk mg/l	Nitrate mg/l NO_3^-	Turbidity NTU	Cond Umho/cm
	Open Water	3:00 PM	24.3	8.3	10.9	131.3	N/S	N/S	N/S	N/S	N/S
		6:00 PM	24.5	8.2	11.5	140.2	9.0	55.0	31.8	6.5	970
		9:00 PM	24.5	8.2	8.4	102.4	N/S	N/S	N/S	N/S	N/S
		12:00 AM	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
		3:00 AM	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
		6:00 AM	23.6	8.5	8.8	103.5	N/S	N/S	N/S	N/S	N/S
		9:00 AM	22.5	8.6	10.0	116.3	8.5	75.0	29.0	3.4	1100
		12:00 PM	24.2	8.3	9.7	116.9	8.6	50.0	29.2	8.2	1005

Table 3
August 28, 2009
Delta Area
Water Quality

Sample Point GPS Coord.	Location Description	Time	Temp ^{0}C	D.O. mg/l	D.O. Sat. mg/l	D.O % Sat	pH	Alk. mg/l	Nitrate mg/l	Turb. NTU	Cond umho
N38°01.200'	Humphrey's	8:00 AM	21.6	8.5	8.8	96.6	7.7	60	28	11	1100
W121°49.164'	Marina										
N38°00.748'	Big Break	9:00 AM	22.7	5.8	8.6	67.4	7.2	70	22	3	1340
W121°43.694'	Pier										
N37°59.005'	Marsh Creek	6:45 AM	24.5	5.0	8.3	60.2	7.7	145	83	120	1570
W121°41.401'	@ Laurel Rd										
N37°57.114'	Marsh Creek .	7:30 AM	21.8	7.0	8.7	80.5	8.0	150	13	53	1250
W121°41.787'	@ Main St										

Eutrophication of Pond at Freedom High School

In 2004, a combination flood retention and environmental study pond was installed at the corners of Neroly and O'Hara roads in Oakley. It was hoped that the pond could serve as an outdoor environmental laboratory for many years to come. A key expectation was the observation of natural succession of organisms over time. The actual rate of succession was faster than anyone could imagine. We have included this as an example of what we believe may be happening widely over the Delta watershed and which is a major driving force for the downturn in the Delta ecosystem.

Figure 7, Pond at Freedom High School, November 10, 2005

Figure seven, above, shows that pond in late 2005, approximately one year after construction. Notice filamentous algae nearly covering the water surface and vegetation beginning to encroach from both sides. At that time, typical benthic invertebrates including damselflies and dragonflies still could be found, especially in the areas with vegetation. In addition, thousands of mosquito fish, which had been introduced for mosquito control, were thriving.

Figure 8, Inlet to Freedom Pond in January 2006.

During the following year, there was very active residential construction in the surrounding neighborhoods. In addition, there were several periods of heavy rain during the winter and spring. Figures 8 and 9 show newly deposited sediment at the inlet to the pond.

Figure 9, Inlet to Freedom Pond in April 2006.

Water samples taken at the time of the above photos showed up to 4 mg/l to 8 mg/l nitrates, low dissolved oxygen, and turbidity in excess of 500 NTU. In addition, typical aquatic invertebrates that might be expected in this pond environment were totally absent.

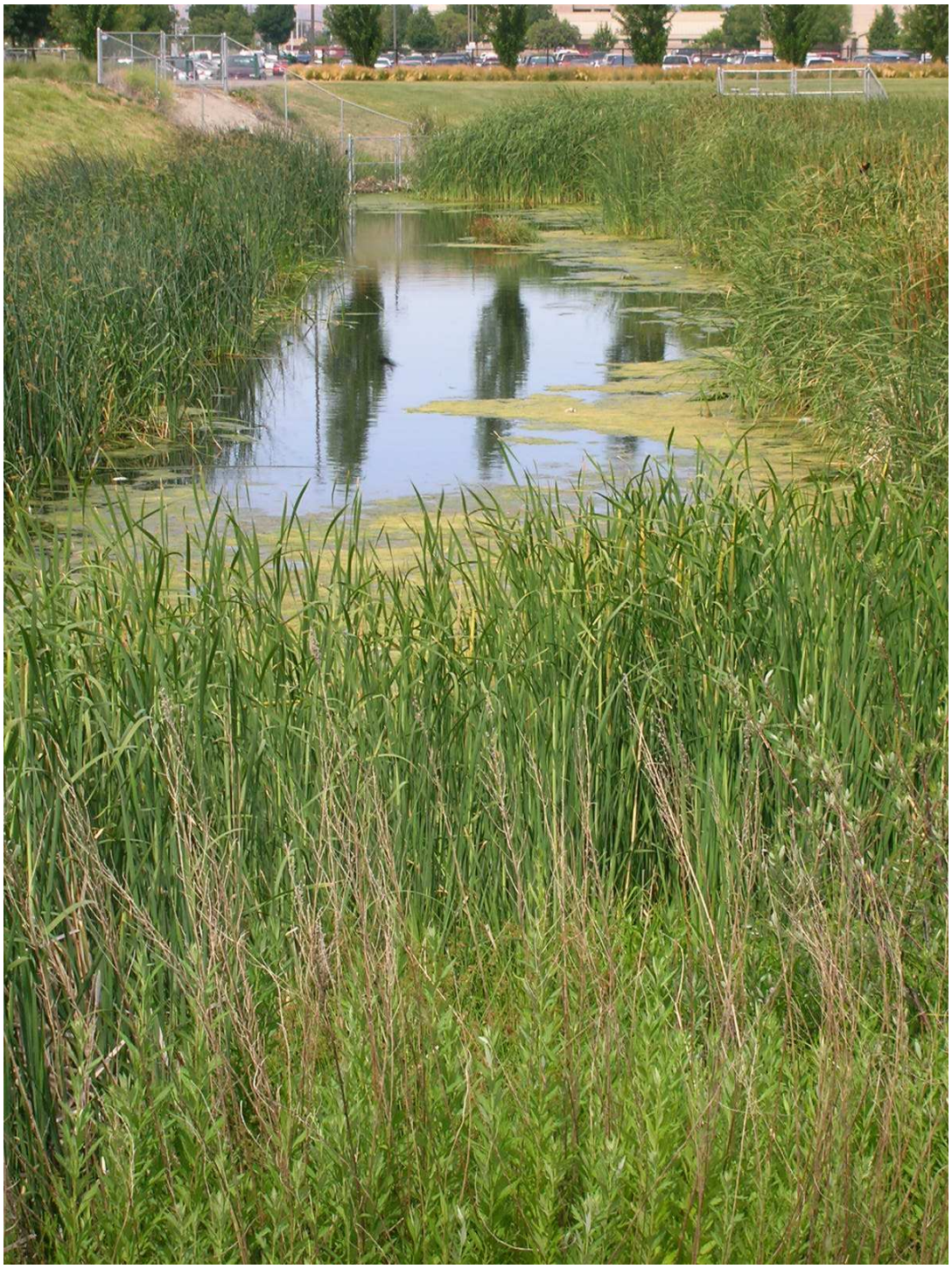

Figure 10, Inlet to Freedom Pond in April 2007.

This is what the pond looked like in June of 2007. Notice that cattails are closing in from both sides and filamentous algae is starting to cover the remaining surface. Nitrate concentrations in the pond water at this time were found in excess of 20 mg/l. During this time period, one could almost watch the changes in vegetation in real time.

Figure 11, Freedom Pond in August 2008.

In August of 2008, only a narrow strip of open water, covered with floating algae is observable. By that time, the water in the pond had begun to smell, and the bottom was covered with black organic material.

Figure 12, Freedom Pond in July 2009

By July of 2009, the pond had essentially filled with sediment and vegetation. The process of eutrophication from open water to meadow had been completed in only about five years. In more natural circumstances, this sort of conversion takes decades at a minimum to perhaps a thousand years or more.

Figure 13, Aerial View of Former Freedom Pond Area, 2009.