Interim Report, 2017 Field Season
Lower San Diego River Aeration Project

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Purpose

This document summarizes data collected as part of the lower San Diego River aeration project. The project objective is to determine the impact of the installation of 5 aerators on dissolved oxygen and water chemistry. The purpose of this report is to document the data collected in the fall 2017 deployment period, and to present lessons-learned for future deployments.

Executive summary

The aerators did not have a detectable impact on dissolved oxygen or water quality. This could be due to the relatively shallow intake depth (1m), the volumetric pumping rate (1000 gph), or the aeration efficiency. Detection of the impact of the aerators is complicated by natural variability in DO, and there is some unexplained variability in DO during the pre-aeration period. Both the continuous data and profiles were valuable in showing DO dynamics. The DO loggers at the surface appear to have malfunctioned about 1 month into the project, possibly due to biofouling. Future deployments should consider increasing the intake depth and an alternate aeration mechanism. Water chemistry results showed little spatial or vertical variability in dissolved organic carbon (DOC) or total dissolved nitrogen (TDN), suggesting that relatively few sampling locations can be used in future campaigns. The lack of spatial variability in DOC and TDN mid-way through the aeration (Nov 16) suggest that the aerators had no detectable impact on water chemistry. The percent organic carbon in sediment had high spatial variability, complicating the possibility of detecting changes in sediment chemistry due to aerator operation, and suggesting that a large number of sediment samples (~15-20) would be needed to detect a change.

1. Aerator deployment and data collection

Five aerators were deployed at the site (Figure 1) on October 5, 2017 at 12 pm. The aerators are the 2015 Savior 10000 Gallon Pond 60-watt Solar Pump Filter and Aerator System from Natural Current (Figure 1.1). The maximum pump rate is 1100 gallons per hour (Evingham, personal communication, 2017-09-13). The aerators were fit with an intake at between 30 cm and 1m depending on the aerator, so water was taken from 1m depth and discharged near the surface with a Venturi jet, which aerates the water.

The aerators were run for testing starting on October 5, 2017 at 12pm and were turned off on October 6, 2017 at 11am in order to provide a baseline of dissolved oxygen concentrations prior to aerator operations.

Figure 1.1. Aerator deployed at the site.

One aerator was temporarily and accidentally on from October 6, 2017 at 4pm to October 7, 2017 9am, but that aerator was far from a logger and we anticipate had minimal impact on the pond-average DO concentration. All aerators were turned back on on October 11, 2017 at 2:30pm. All aerators were removed on November 30, 2017.

Loggers that record dissolved oxygen and water temperature were deployed at three different locations, including a deep pool, a shallower location east of a small island, and west of the island (Figure 1). Loggers were installed and operational on October 5, 2017 until December 20, 2017. The loggers recorded DO and temperature at 5-minute intervals. Data were downloaded at approximately monthly intervals. Profiles of DO and temperature were taken at weekly to bi-weekly intervals throughout the project at the loggers and at two locations downstream that served as controls. Since the exact location could not be visited each time using the boat, profile locations are reported as occurring in small regions. During the profile collections, water samples were collected for analysis of dissolved organic carbon and total dissolved nitrogen at the two logger locations with the aerators, collected at the surface (30 cm) and at depth (50 cm from the bottom). Samples were filtered with 0.7 micron glass fiber filters and stored frozen until analysis. Sediment samples were collected at the logger locations in August and December, 2017 and analyzed for carbon content using the loss-on-ignition method.

Figure 1.2. Map of the aerators, data loggers, and profile locations. The loggers and profile points are labelled. P1=pool 1, P2=pool 2, CDE = Camino del Este.

2. Meteorological conditions

Data on air temperature, wind speed and cloud cover were available for Montgomery Field station, which is 4.3 km north of the field site. Data on daily mean air temperature and daily mean wind speed are hosted by the National Climate Data Center (NCDC). Cloud cover data are hosted by Mesowest (http://mesowest.utah.edu/), reported in 5 minute increments, and were aggregated to daily, day-time averages for this analysis. Cloud cover is reported in categories (clear, scattered, broken, overcast), which have a cloud cover value (in okta, or eighths of the sky) associated with them. Daily cloud cover percentage was calculated as the mean of the 5-minute percentage values during daytime only (7am-5pm). Clear sky fraction is calculated as 1-(cloud cover fraction). Data on solar energy generation were also available for a private residence near San Diego State University; values in W-h for each day were normalized to the maximum output observed in August, 2017. The solar energy and cloud data together give a quantitative picture of cloud cover and solar output at the site, but do not translate directly to solar output on the aerators.

Fall 2017 was unusually warm, and several high-temperature records were broken in San Diego, including a high of 92 F the week of November 22nd (Times of San Diego, 2017). The time series of temperature from the Montgomery Field station shows several heat waves in October and November (Figure 1), with mean daily temperatures of up to 86 F. The heat waves were associated with cloudless conditions, and cloud cover was relatively low and clear sky fraction high during most of October and November. Cloud cover increased, temperatures decreased, and wind increased together during several cloudy events in October-December. A few high-wind days were observed during the period, including in early October before the aerators were turned on, in late October while aerators were operational, and in December after the aerators were removed.

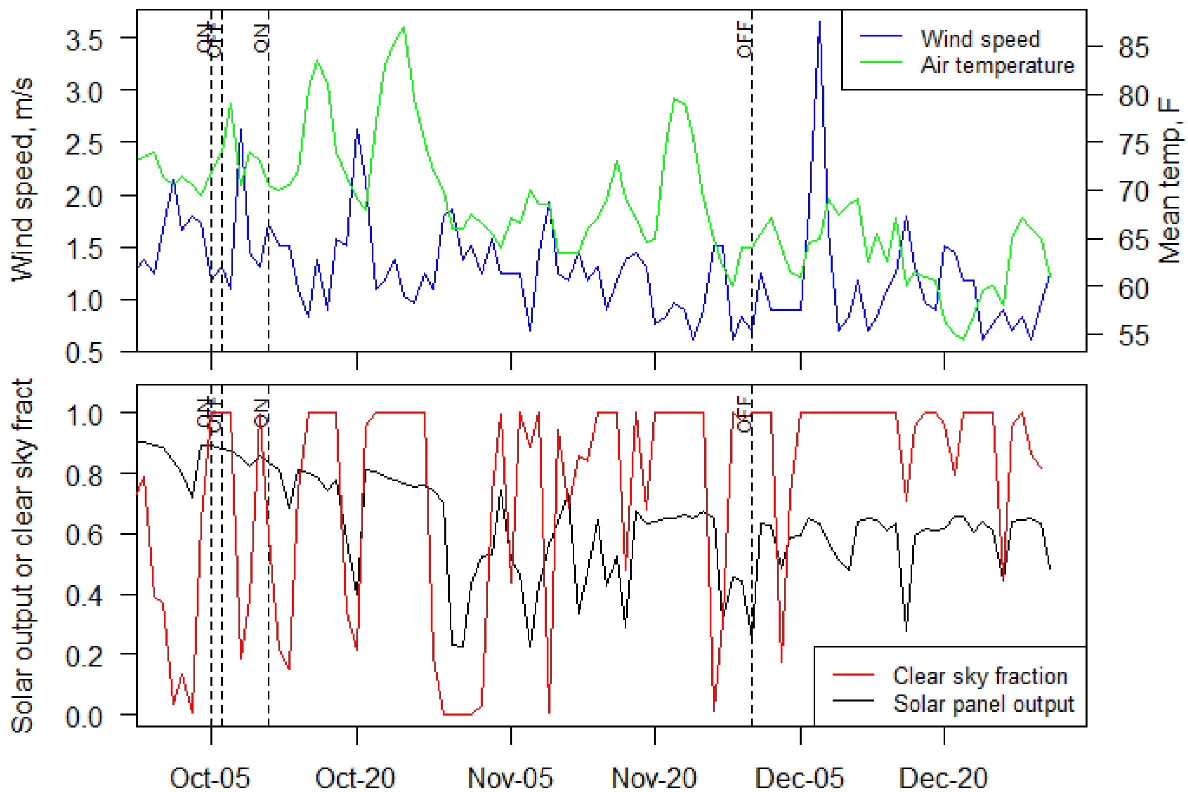

Figure 2.1. Time series of solar output, clear sky fraction (1-cloud cover fraction), wind speed and air temperature. Dashed lines indicate when the aerators were turned on ("ON") and off ("OFF").

3. Dissolved oxygen loggers

The DO data appeared reliable through November 5, 2017, after which the loggers near the surface (Loggers 2, 3 and 6) behaved erratically. The erratic measurements stopped temporarily after the aerators were removed and cleaned on Nov 30, but then resumed erratic behavior by Dec 5. The loggers at depth showed no irregular behavior, suggesting that the problem with the surface loggers was due to biofouling.

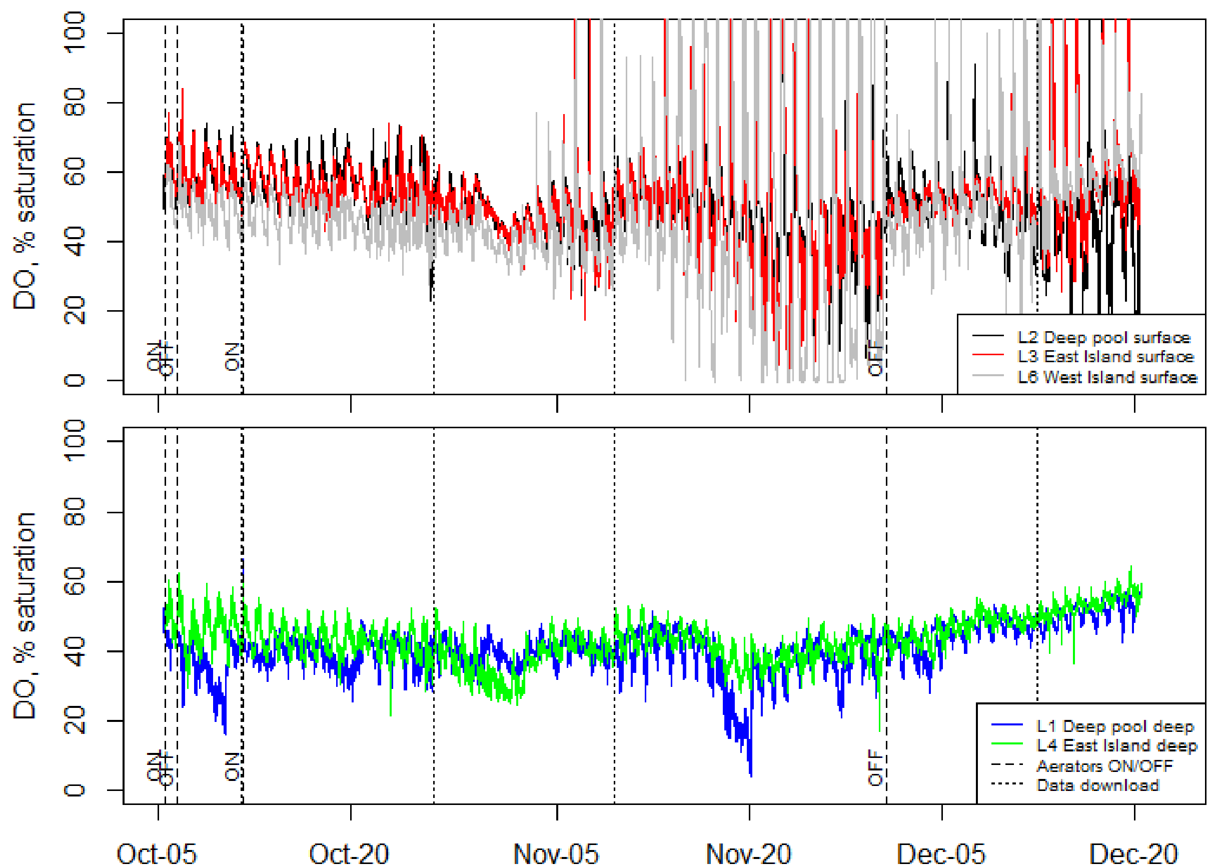

Figure 3.2. Time series of dissolved oxygen (DO, % saturation) for all five loggers, with dashed lines indicating when the aerators were turned on ("ON") and off ("OFF") and when data were downloaded.

There were no significant trends in DO during the aerator deployment (Figure 3.1, 3.2). Logger 6 was located on the west side of the island where the impact of the aerators is assumed to be small, and serves as a control. There were no notable differences in the DO timeseries between the aerated sites and the control site. DO increased from November 20 to December 20, but the rate of increase was the same whether the aerators were on (Nov 20-Nov 30) or off (Nov 30-Dec 20). Overall, the data suggest that the aerators had limited impact on DO concentrations or percent saturation, both at surface and at depth.

The period with high-quality DO data (Oct 5-Nov5) also shows limited difference between loggers near the aerators (L2 and 3) and a control logger (L6). L6 had lower DO concentrations during the entire period, perhaps because it was located deeper than the other two loggers, but DO was also lower west of the island for other reasons, perhaps due to increasing DO consumption from decaying organic matter. DO at the control (L6) was lower both before and after deployment of the aerators, so the higher values at L2 and L3 cannot be attributed to the aerators.

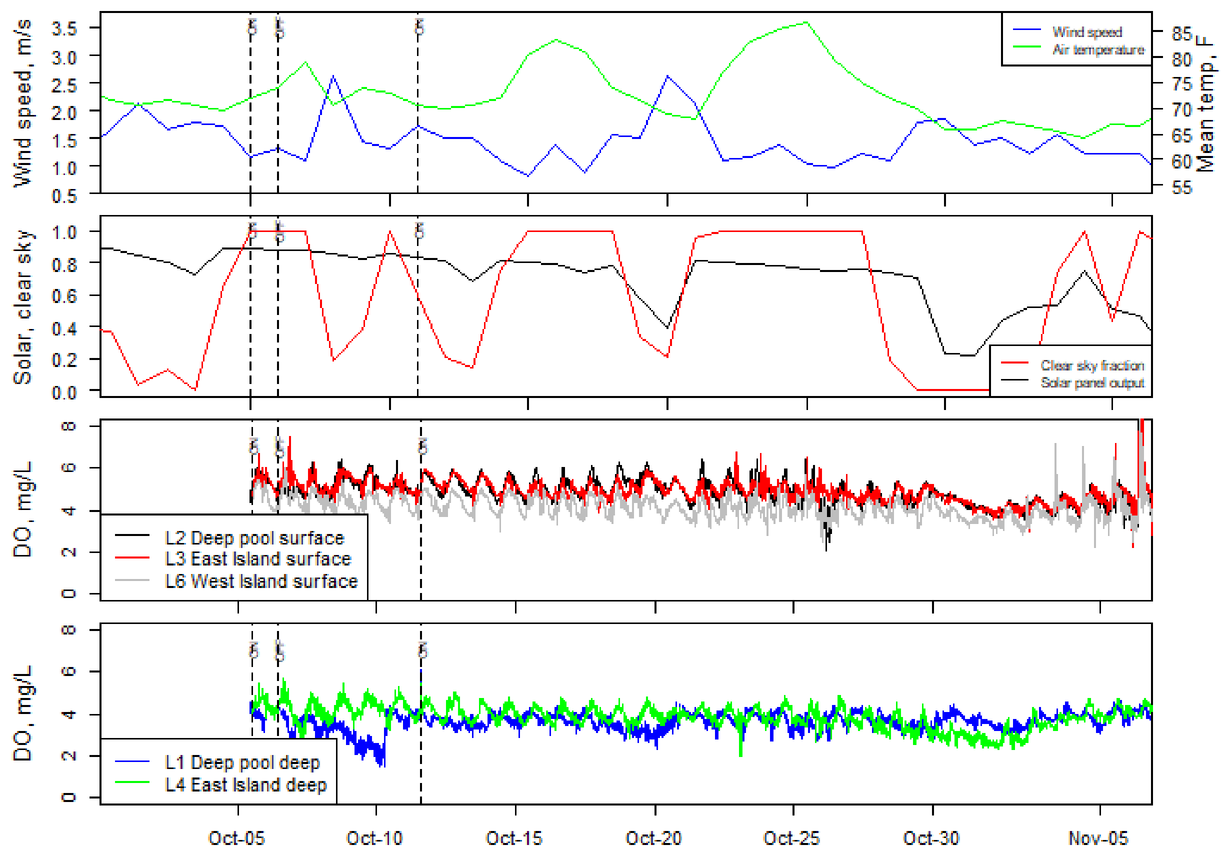

Figure 3.3. Time series of meteorological conditions, solar energy and DO at the logger sites.

The DO at the surface reached a minimum in the early to mid-morning (6-10am), and increased through mid-day, reaching a maximum in the mid to late afternoon (~4-5 pm) (Figure 3.4). This suggests that DO profiles need to be taken before ~10am to ensure consistency.

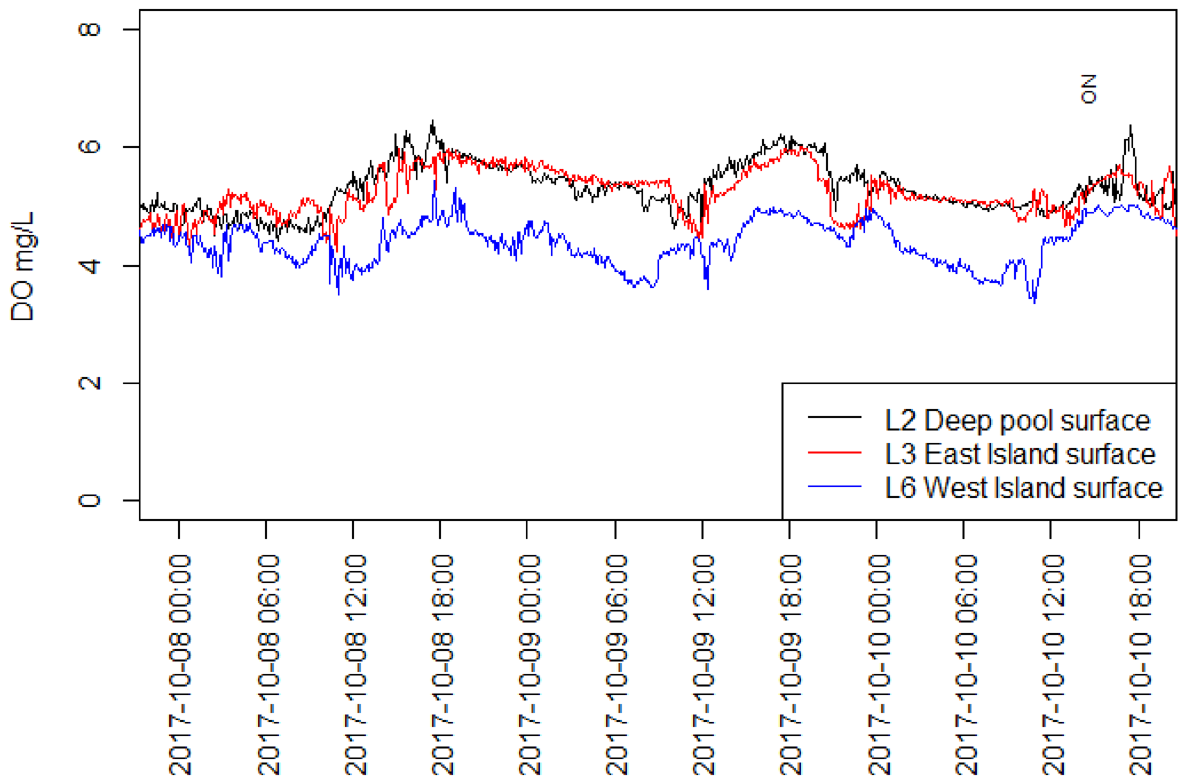

Figure 3.4. Plot of DO at surface loggers to show diurnal variations.

4. Dissolved oxygen profiles: Single locations over time

Dissolved oxygen (DO) and temperature generally decreased with depth at all sampled locations. The deep pool at loggers 1 and 2 had the lowest DO concentrations of the aerated pool, down to 2.7 mg/L on October 19, 2017 (Figure 4.1), though concentrations at the loggers in the deep pool were lower than that at some times of day . DO concentrations decreased at most depths after the aerators were turned on (October 11, 2017) for all dates except for November 16, when concentrations increased at all depths, presumably due to destratification and mixing. While profiles were taken for other dates, we focus here on the week October 5 to November 16. DO decreased the most between 80 cm and 150 cm, and below 300 cm (Figure 4.1).

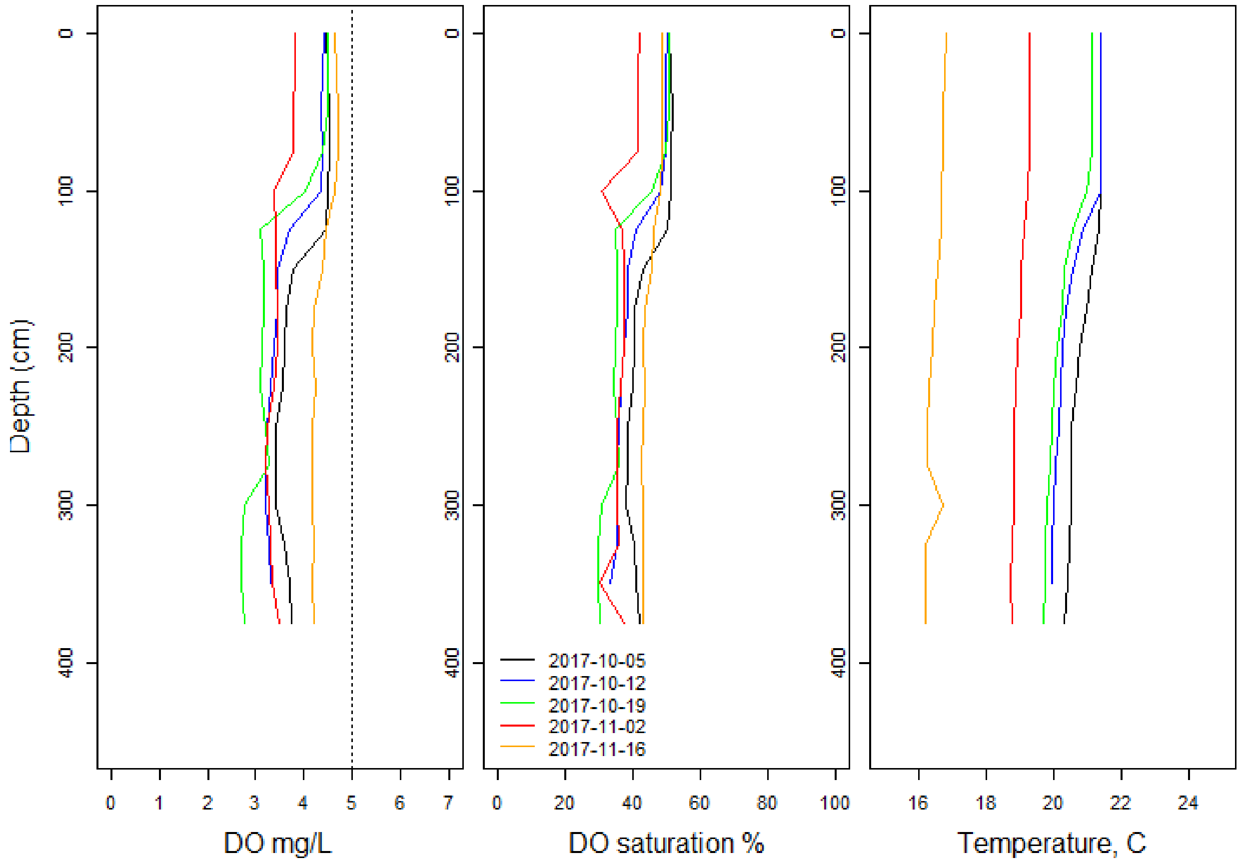

Figure 4.1. Profiles of DO, DO saturation, and water temperature at the pool near Qualcomm way (Site xx in Figure 1.1).

DO behaved similarly east of the island, where DO also decreased between October 5 and November 2, with the most rapid decreases below 50 cm.

These results are consistent with patterns observed in the DO timeseries from the dataloggers (Figure 3.1-3.2), which show DO decreasing at depth between October 5 and November 2, with recovery around November 5. The surface loggers also showed gradually decreasing DO from October 5 to November 2, with increases starting November 1-3.

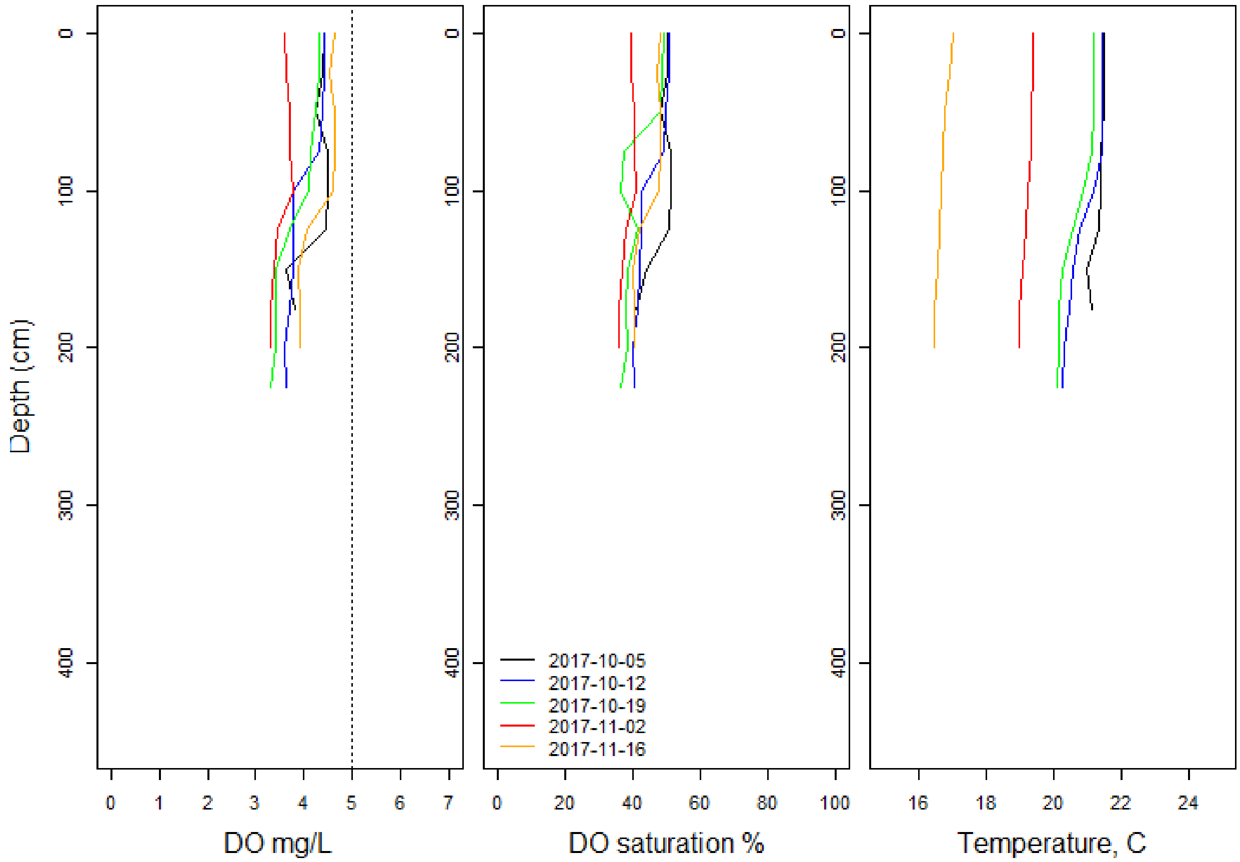

Figure 4.2. Profiles of DO, DO saturation, and water temperature at the pool east of the island (Site xx in Figure 1.1).

5. Aqueous and sediment chemistry

Samples were taken at 30 cm below the surface and 75 cm above the bottom at the same locations as the DO profiles. Samples were filtered through 0.7 micron glass fiber filters in the field and frozen until analysis.

Both DOC and TDN do not vary significantly over space for the date with the most comprehensive data, November 16, 2017 (Table 5.1); the maximum and minimum values vary from 6.2 to 7.1 mg DOC/L and 0.34 to 0.48 mg TDN/L. There was no marked difference between DOC and TDN in the inflow (“upstream”) and the outflow (“downstream”), though TDN was lower downstream for this sampling date. The maximum and minimum DOC values were 5% and 8% different from the mean of all sites and depths, and the maximum and minimum TDN were 16% and 18% different from the mean of all sites and depths. There was no systematic difference in DOC or TDN between the surface (30 cm) and depth (75 from the bottom). This very low spatial and vertical variability in DOC and TDN suggests that relatively few sample locations are needed to successfully monitor them at this location.

The molar (atomic) C:N ratio was between 16 and 24 (Table 5.1). This is near the Redfield ratio (16:1) indicating an algal source of C and N, with a slight excess of C that may be from allocthononous C sources (leaves) that have a low C:N.

Table 5.1. Water chemistry for samples collected on November 16, 2017, including dissolved organic carbon (DOC) and total dissolved nitrogen (TDN), in mg/L, and the molar C:N ratio. "Surf" is collected at 30 cm below the surface, and "Depth" is 75 cm from the bottom. Sample locations correspond to Figure 1.2.

Sample location	DOC	TDN	C:N
Upstream	6.7	0.48	16
Downstream	6.8	0.39	21
P1.Qual.Surf	6.9	0.42	19
P1.Qual.Depth	7.0	0.48	17
P1.EastIsland.Surf	6.9	0.41	20
P1.EastIsland.Depth	6.7	0.38	21
P1.CDE.Surf	7.1	0.36	24
P1.CDE.Depth	6.2	0.34	21
P2.CDE.Surf	6.9	0.48	17
P2.CDE.Depth	6.9	0.42	19

Sediment samples were collected at 6 locations (Figure 5.1). Organic matter percentage (OM) was determined using the loss-on-ignition method, and each sample was analyzed three times. OM differed significantly among sites, from a low of 0.9% to a high of 8.1% (Table 5.2). Replicates at a single site were within 10% of the mean for all locations except for Site B, which had higher variability due to the low mean concentration (0.7%). The results suggest that OM analysis was robust for a given sample, and that OM varies significantly over space in the study area. In fact, the largest and smallest OM were at the sites that were closest to each other (A and B). The large spatial variability in OM complicates the potential to detect changes in OM% before and after management actions like aeration.

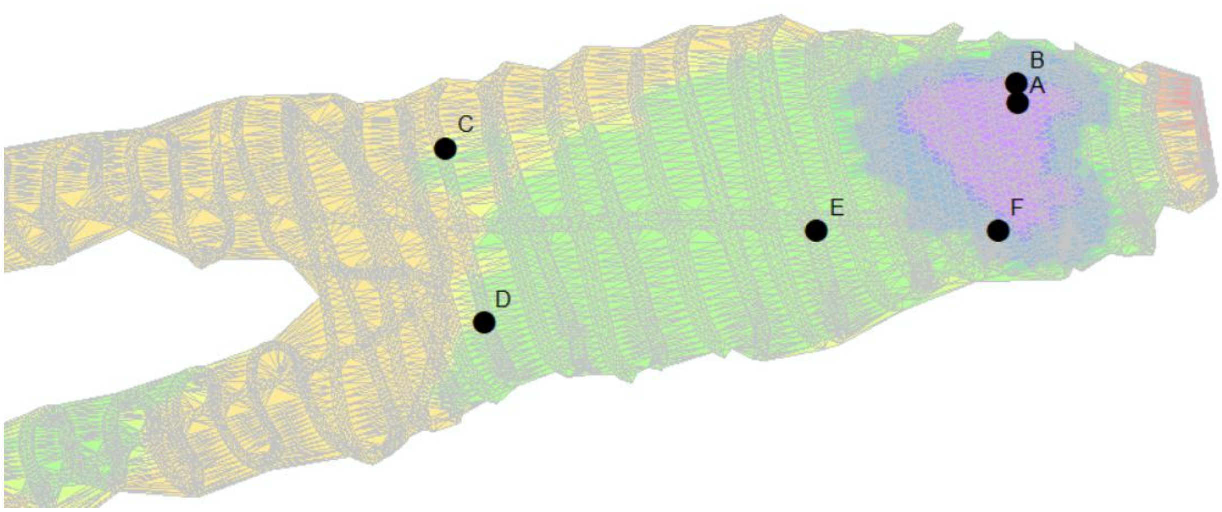

Figure 5.1 Locations of sediment sample collection, October 2017, overlain on a bathymetry map (courtesy of SonTek).

Table 5.2. Sediment organic matter content, % of dry weight.			
	Min	Mean	Max
A	7.7	8.1	8.4
B	0.7	0.9	1.1
C	5.2	5.4	5.7
D	1.7	1.7	1.7
E	2.1	2.3	2.5
F	4.4	4.5	4.5

References

Times of San Diego, https://timesofsandiego.com/life/2017/11/22/heat-wave-smashes-temperature-records-in-san-diego-more-on-tap-for-thanksgiving/