Continuous Environmental Monitoring Program

Background

The Continuous Environmental Monitoring Program provides real-time quarter-hourly water quality and environmental data from 15 automated sampling stations in the estuary (Figure 1). The stations provide continuous measurements of 6 water quality parameters and up to 4 environmental parameters at select locations. These measurements are used by operators of the State Water Project (SWP) and the Central Valley Project (CVP) to assess the impacts of the project operations and to adjust project operations to comply with mandated water quality standards. The continuous monitoring program has been in operation since 1983. This chapter summarizes the results of continuous water quality monitoring at 15 sites for calendar year 2018. The stations are categorized into five regions. (Table 1, Figure 1): Northern Interior Delta, Southern Interior Delta, Central Delta, Confluence, and Grizzly & Suisun Bays.

Table 1 – Regions of EMP, Field

Northern Interior Delta stations:	C3A (Hood), D24A (Rio Vista)
Central Delta stations:	D16A (Twitchell Island), D19A (Franks Tract), D29 (Prisoner's Point)
Southern Interior Delta stations:	P8A (Stockton), C7A (Mossdale), C10A (Vernalis)
Confluence stations:	D11A (Sherman Island), D12A (Antioch), D10A (Mallard Island)
Grizzly and Suisun Bay stations:	D9A (Honker Bay), D8A (Ryer Island), D7A (Grizzly Bay), D6A (Martinez)

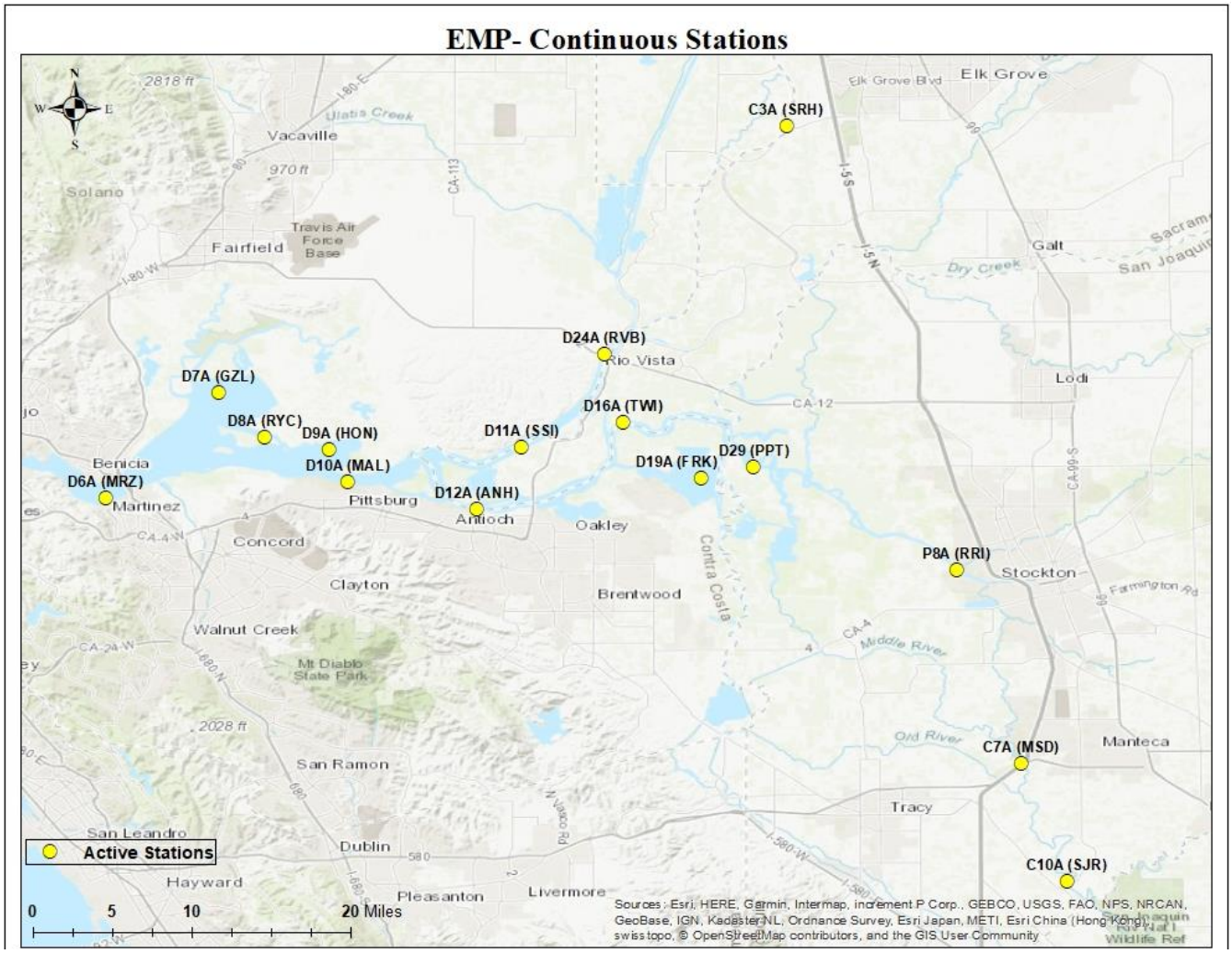

Figure 1

Methods

Continuous data were collected for the water quality and environmental parameters shown in Table 2. Each of the 15 monitoring stations collected continuous data for water temperature (WT), pH, dissolved oxygen (DO), surface specific conductance (SpC), chlorophyll *a* fluorescence, and turbidity. Additional sensors were installed at the Antioch, Mallard Island, and Martinez stations in the 1990's to monitor bottom SpC. These measurements, along with river stage data measured at the Mallard Island and Martinez stations, were needed to determine compliance with the salinity standard (also known as X2) that was mandated by the *Bay-Delta Plan* (SWRCB, 1995).

Environmental data, such as air temperature (AT), solar radiation (SRI), wind speed (WV), and wind direction (WD), were measured at all stations as part of D-1641's Table 3 objectives (SWRCB, 1999). The only environmental parameter analyzed for this chapter was air temperature from a MET-1 Instrument Mod. 062 sensor.

Except for bottom SpC, all water samples were collected at 1-m below the water surface using a float-mounted YSI 6600 or EXO2 multi-parameter water quality sonde. In contrast, bottom SpC was measured at 1.5 m above the channel bottom using a YSI EXO1 sonde. Water quality data and environmental data were recorded at 15-minute intervals.

QA Status

On a monthly basis, quality assurance and control measures were applied using field verification data sheets. Data affiliated with instrument issues were flagged and excluded from the analysis.

Table 1 – Rating criteria for continuous sonde calibration

	Excellent	Good	Fair	Poor
Water Temperature (°C)	≤±0.2	±0.2-0.5	±0.5-0.8	>±0.8
Specific Conductance (µS/cm)	≤±3%	±3-10%	±10-15%	>±15%
Dissolved Oxygen (mg/L)	≤±0.3 or ≤±5%	±0.3-0.5 or ±5-10%	±0.5-0.8 or ±10-15%	>±0.8 or >±15%
pH	≤±0.2	±0.2-0.5	±0.5-0.8	>±0.8
Turbidity (NTU)	≤±0.5 or ≤±5%	±0.5-1.0 or ±5-10%	±1.0-1.5 or ±10-15%	>±1.5 or >±15%

Results

The daily averages of the continuous 15-minute data collected for air and water temperature, pH, DO, surface and bottom SpC, chlorophyll *a* fluorescence, and turbidity for calendar year 2018 are shown in Figures 2 to 8. The range of monthly DO values at the Stockton station is shown in Figure 9. Data gaps in the daily plots result from days where more than 34% of the 15-minute data are flagged or unavailable.

The Northern Interior Delta stations had surface specific conductance values that ranged from 74 µS/cm (C3A in April) to 2,575 µS/cm (D24A in November). Surface turbidity values ranged from 0.98 NTU (C3A in November) to 133.9 NTU (C3A in December). Surface water temperature values ranged from 8.44 °C (C3A in November) to 23.63 °C (C3A in October). Surface dissolved oxygen values ranged from 7.19 mg/L (D24A in June) to 11.1 mg/L (C3A in February). Surface pH values ranged from 6.99 (C3A in October) to 7.96 (C3A in April). Surface fluorescence values ranged from 0.18 µg/L (D24A in December) to 13.92 µg/L (D24A) in October.

	Specific Conductance (µs/cm)	Turbidity (NTU)	Water Temperature (°C)	Dissolved Oxygen (mg/L)	pH	Fluorescence (µg/L)
	Surface	Surface	Surface	Surface	Surface	Surface
MIN	74	0.98	8.44	7.19	7.28	0.18
MAX	2,575	133.9	23.63	9.67	8.2	13.92
AVERAGE	173	8.09	16.34	8.99	7.52	1.81

The Central Interior Delta stations had surface specific conductance values that ranged from 127 µS/cm (D16A in April) to 3,248 µS/cm (D16A in November). Surface turbidity values ranged from 0.01 NTU (D19A in November) to 330.9 NTU (D29 in January). Surface water temperature values ranged from 8.81 °C (D19A) in December) to 25.12 °C (D19A in October). Surface dissolved oxygen values ranged from 6.03 mg/L (D29 in August) to 15.72 mg/L (D19A in February). Surface pH values ranged from 7.13 (D16A in February) to 9.64 (D19A in September). Surface fluorescence values ranged from 0.1 µg/L (D19A in October) to 13.6 µg/L (D19A) in April.

	Specific Conductance (µs/cm)	Turbidity (NTU)	Water Temperature (°C)	Dissolved Oxygen (mg/L)	pH	Fluorescence (µg/L)
	Surface	Surface	Surface	Surface	Surface	Surface
MIN	127	0.1	8.81	6.03	7.13	0.1
MAX	3248	330.9	25.12	15.72	9.64	13.6
AVERAGE	453	6.16	17.00	9.28	7.83	2.75

The Southern Interior Delta stations had surface specific conductance values that ranged from 129 µS/cm (C10A in May) to 1,033 µS/cm (P8A in September). Surface turbidity values ranged from 0.12 NTU (P8A in February) to 204.1 NTU (C7A in March). Surface water temperature values ranged from 8.15 °C (C10A in December) to 29.2 °C (C10A in July). Surface dissolved oxygen values ranged from 4.72 mg/L (C7A in July) to 17.98 mg/L (C7A in August). Surface pH values ranged from 7.15 (P8A in June) to 9.47 (C10A in July). Surface fluorescence values ranged from 0.53 µg/L (P8A in February) to 75.9 µg/L (C7A) in June.

	Specific Conductance (µs/cm)	Turbidity (NTU)	Water Temperature (°C)	Dissolved Oxygen (mg/L)	pH	Fluorescence (µg/L)
	Surface	Surface	Surface	Surface	Surface	Surface
MIN	129	0.12	8.15	4.72	7.15	0.53
MAX	1,033	204.1	29.2	17.98	9.47	75.9
AVERAGE	518	11.85	17.53	9.34	7.78	8.05

The Confluence stations had surface specific conductance values that ranged from 83 µS/cm (D11A in April) to 22,450 µS/cm (D10A in November). Bottom specific conductance values ranged from 124 µS/cm (D10A in April) to 24,083 µS/cm (D10A in November). Surface turbidity values ranged from 1.96 NTU (D12A in November) to 84 NTU (D10A in July). Surface water temperature values ranged from 9.04 °C (D11A in December) to 23.63 °C (D12A in August). Bottom water temperature values ranged from 9.29 °C (D12A in December) to 23.49 °C (D12A in July). Surface dissolved oxygen values ranged from 7.36 mg/L (D12A in June) to 11.4 mg/L (D12A in February). Surface pH values ranged from 7.58 (D11A in January) to 7.74 (D10A in April). Surface fluorescence values ranged from 0.1 µg/L (D11A in January) to 10.42 µg/L (D10A) in October.

	Specific Conductance (µs/cm)		Turbidity (NTU)	Water Temperature (°C)		Dissolved Oxygen (mg/L)	pH	Fluorescence (µg/L)
	Surface	Bottom	Surface	Surface	Bottom	Surface	Surface	Surface
MIN	83	124	1.96	9.04	9.29	7.36	7.58	0.1
MAX	22,450	24,038	84	23.63	23.49	11.4	7.74	10.42
AVERAGE	3,432	4,766	12.53	16.46	16.48	9.07	7.72	2.35

The Grizzly Suisun Bay stations had surface specific conductance values that ranged from 101 µS/cm (D9A in April) to 38,580 µS/cm (D6A in November). Bottom specific conductance values ranged from 182 µS/cm (D6A in April) to 38,841 µS/cm (D6A in November). Surface turbidity values ranged from 0.93 NTU (D6A in December) to 763.2 NTU (D7A in July). Surface water temperature values ranged from 9.03 °C (C7A in December) to 24.4 °C (D6A in July). Bottom water temperature values ranged from 9.90 °C (D6A in January) to 22.53 °C (D6A in July). Surface dissolved oxygen values ranged from 5.09 mg/L (D7A in October) to 16.92 mg/L (D7A in February). Surface pH values ranged from 6.94 (D9A in March) to 9.12 (C7A in March). Surface fluorescence values ranged from 0.1 µg/L (D9A in January) to 144.1 µg/L (D7A) in January.

	Specific Conductance (µs/cm)		Turbidity (NTU)	Water Temperature (°C)		Dissolved Oxygen (mg/L)	pH	Fluorescence (µg/L)
	Surface	Bottom	Surface	Surface	Bottom	Surface	Surface	Surface
MIN	101	182	0.93	9.03	9.90	5.09	6.94	0.1
MAX	38,580	38,841	763.2	24.4	22.53	16.92	9.12	144.1
AVERAGE	13,113	23,738	40.91	16.09	16.06	8.92	7.84	3.38

Water Temperature

Average daily water temperatures in the estuary ranged from 16.09 °C to 17.53°C, with the lower values in the Grizzly/Suisun Bay locations and the higher values found in the Southern Interior Delta stations.

Average daily water temperatures at the Northern Interior Delta stations were usually lower in comparison to the Southern Interior Delta stations, with the most significant divergence occurring July through September at the Southern Interior Delta locations.

Specific Conductance

Daily average surface specific conductance for the estuary ranged from 170 µS/cm to 13,113 µS/cm, with the lower values in the Northern Interior Delta stations and the higher values at the more tidally influenced Grizzly/Suisun Bay locations (Figure 3e).

All stations showed a decrease in specific conductance values in late March (Figure 3a to 3e). The Northern Interior Delta station C3A showed a significant jump in specific conductance values for October and November 2018. In addition, the Southern Interior Delta stations on the San Joaquin River showed a significant decrease in surface specific conductance values in April 2018 after the April VAMP pulse (Figure 3b). Specific conductance values from these three stations would remain low until the beginning of June.

Bottom SpC measured in 2018 at D12A, D10A, and D6A stations exhibited seasonal patterns and range similar to the surface SpC values measured at those stations (Figure 3f).

DO

The average daily DO values in the estuary ranged from 8.99 mg/L to 9.34 mg/L (Figure 4a to 4e). The highest degree of variability was seen at the Southern Interior Delta stations ranging from 5.7 mg/L at P8A in August 2018 to 13.8 mg/L at C7A in June 2018.

All compliance monitoring stations recorded daily averages above the standard of 5.0 mg/L that was set by the CVRWQCB in the *Basin Plan* (CVRWQCB, 1998). The P8A station, located in Southern Interior Delta, started recording lower values that approached the baseline standard of 5.0 mg/L in August 2018. The P8A station showed a DO sag to 5.7 mg/L in August 2018. The monthly average DO levels at the Stockton station did not fall below the 5.0 mg/L standard that was set by the CVRWQCB (1998). The monthly average DO levels did not drop below the 6.0 mg/L standard (SWRCB, 1995) for the passage of fall-run Chinook salmon through the ship channel for the September through November 2018 control period

pH

Daily average pH levels at all stations in the estuary ranged from 7.52 to 7.84 (Figure 5a to 5e). The Southern Interior Delta stations showed a significant increase in daily average pH beginning June 2018 to October 2018 (Figure b). Values ranged from a low of 7.2 at P8A in June 2018 to a high of 9.5 at C7A in July 2018. The Central Delta statin D19A showed an increase in pH values beginning May 2018 until November 2018 (Figure 5c).

Turbidity

Daily average turbidity levels at all stations in the estuary ranged from 6.16 to 40.91 (Figure 6a to 6e). The Northern Interior and Southern Interior Delta stations showed significant increase in daily average turbidity beginning March 2018 to May 2018 (Figure 6b). Values ranged from a low of 7.2 at P8A in June 2018 to a high of 9.5 at C7A in July 2018. The Central Delta statin D19A showed an increase in turbidity values beginning May 2018 until November 2018 (6c).

Chlorophyll *a* Fluorescence

Daily average chlorophyll *a* fluorescence recorded at all the stations ranged from a low of 0.36 µg/L in December 2018 for the Northern Interior Delta station D24A to a high of 57.15 µg/L in July 2018 for the Southern Interior Delta station C7A (Figure 7a to 7e).

For most of the 2018 calendar year, daily fluorescence averages at Southern Interior Delta stations were higher than other regions with sustained higher values from June 2018 through September 2018 except for P8A (Figure 7b).

Air Temperature

Daily average air temperatures in the estuary ranged from 6.4 °C in February 2018 at Grizzly/Suisun Bay station D6A to 30.0 °C in June 2018 at the Northern Interior Delta station D24A (Figure 8a to f).

References

[CVRWQCB] Central Valley Regional Water Quality Control Board. (1998). *Water Quality Control Plan for the California Regional Water Quality Control Board Central Valley Region, the Sacramento River Basin, and San Joaquin River Basin* [*Basin Plan*] (4th ed.).

[SWRCB] State Water Resources Control Board. (1995). *Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Estuary* [*Bay-Delta Plan*] (Adopted May 22, 1995, pursuant to Water Right Order 95-1). Sacramento, CA.

[SWRCB] State Water Resources Control Board. (1999). *Water Rights Decision 1641 for the Sacramento-San Joaquin Delta and Suisun Marsh* (Adopted December 29, 1999, Revised in Accordance with order WR2000-02 March 15, 2000). Sacramento, CA.

Appendix

Figure 1a Average daily water temperature Northern Interior Delta, 2018

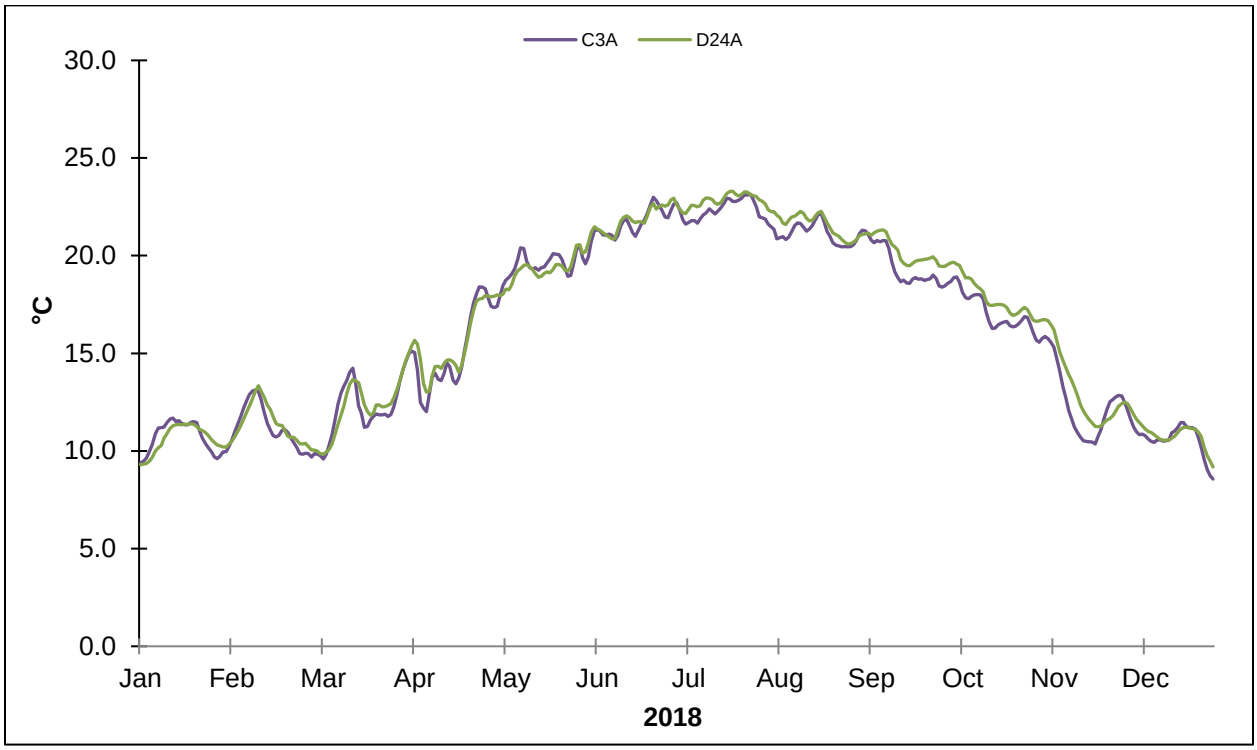

Figure 2b Average daily water temperature Southern Interior Delta, 2018

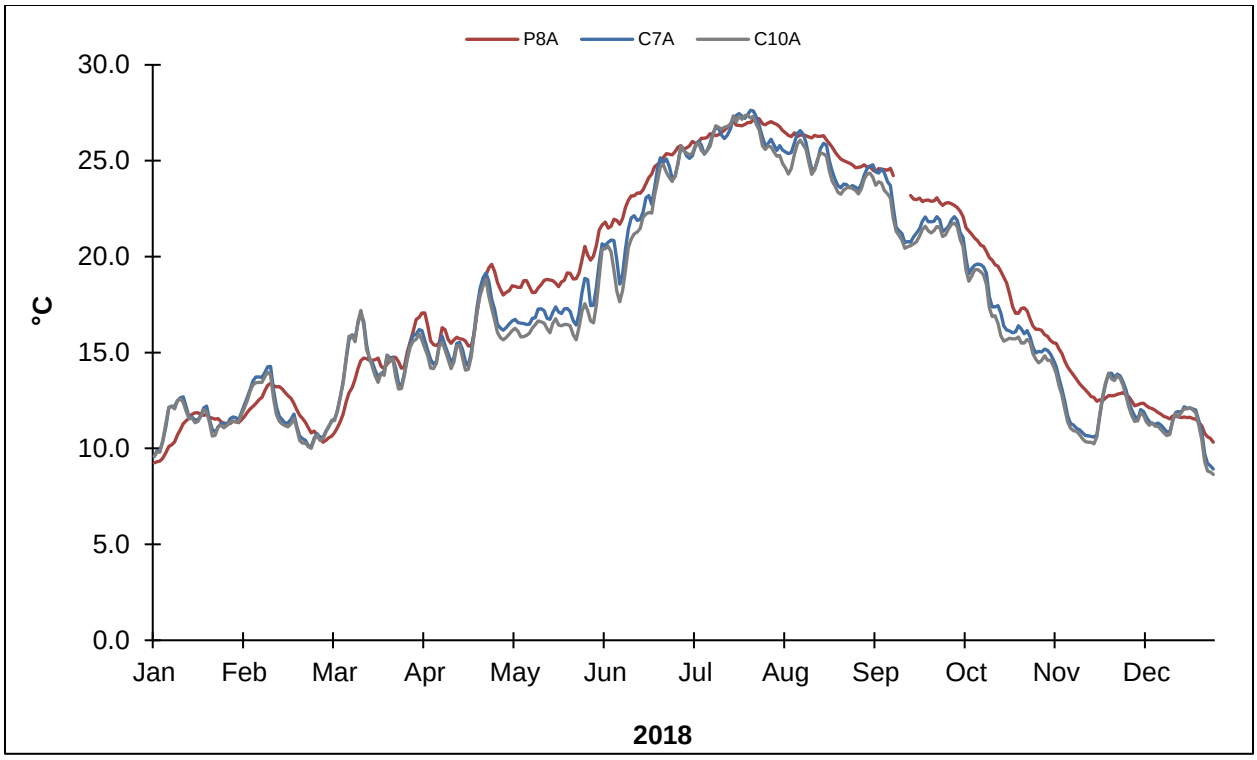

Figure 3c Average daily water temperature Central Delta, 2018

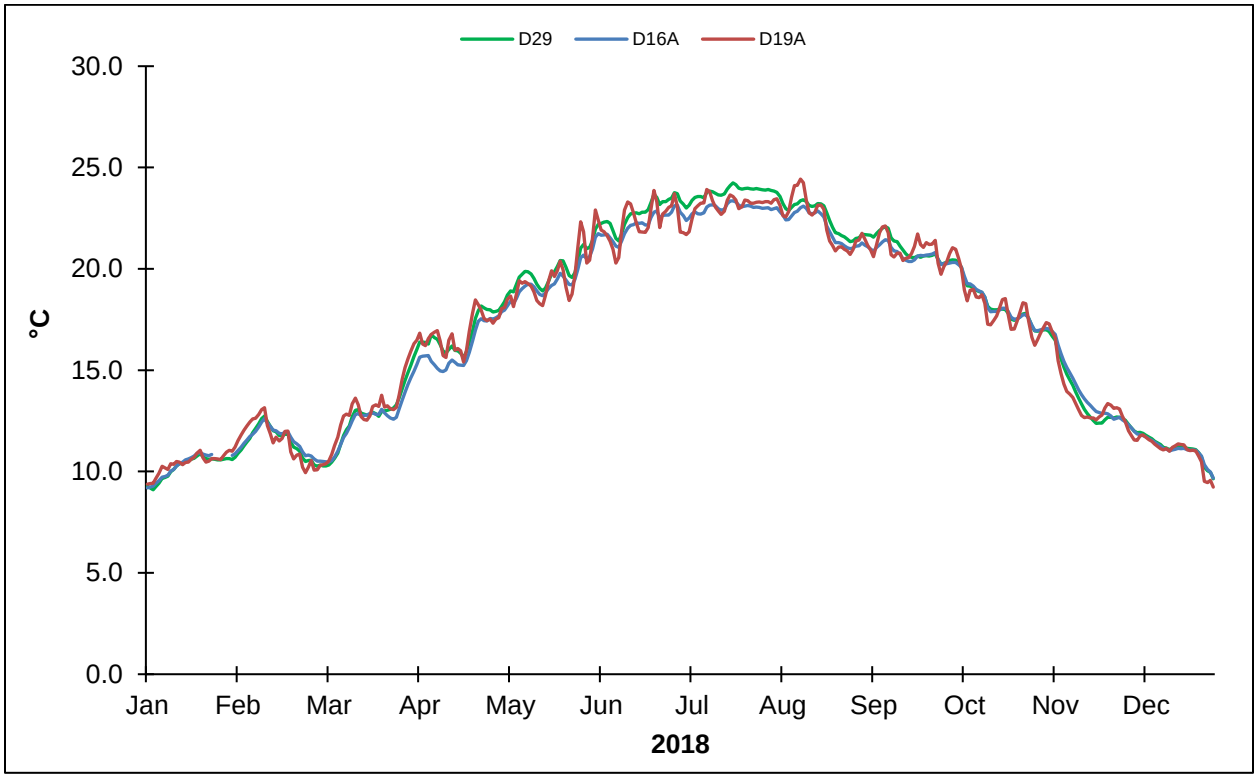

Figure 4d Average daily water temperature Confluence, 2018

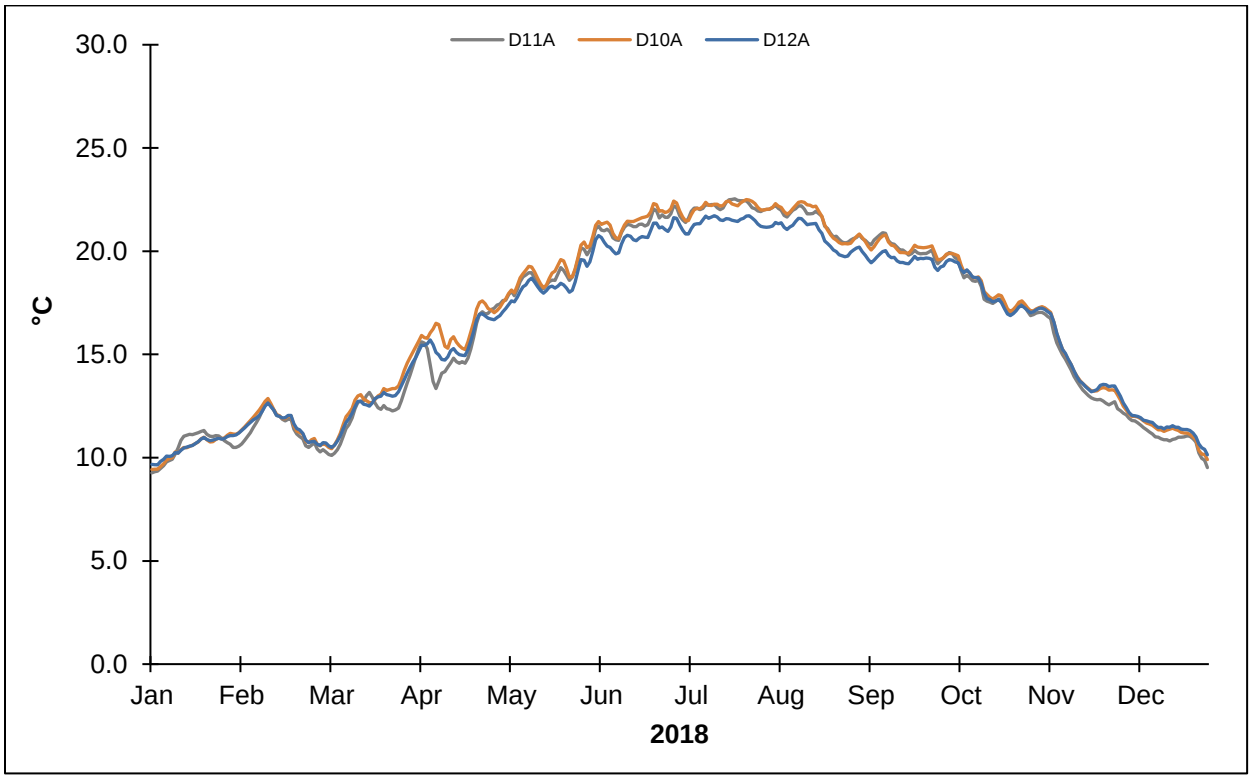

Figure 5e Average daily water temperature Grizzly/Suisun Bay, 2018

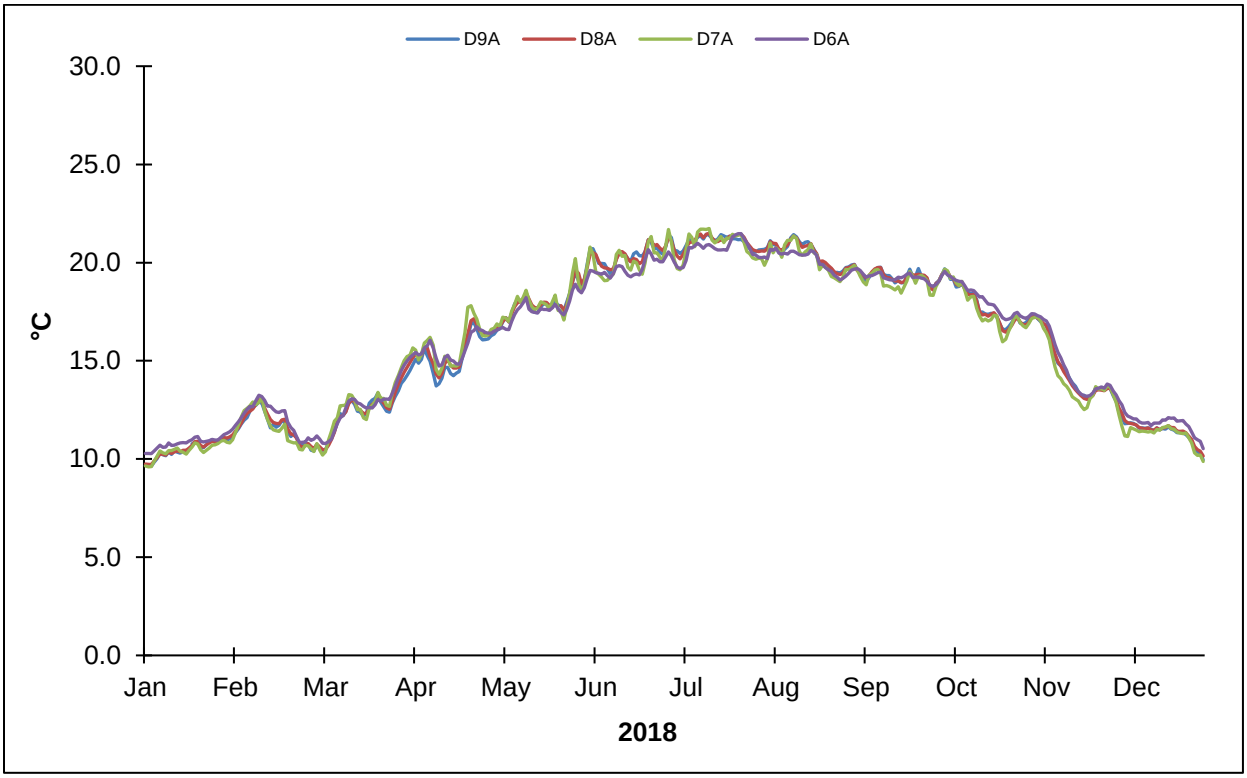

Figure 3a Average daily specific conductance Northern Interior Delta, 2018

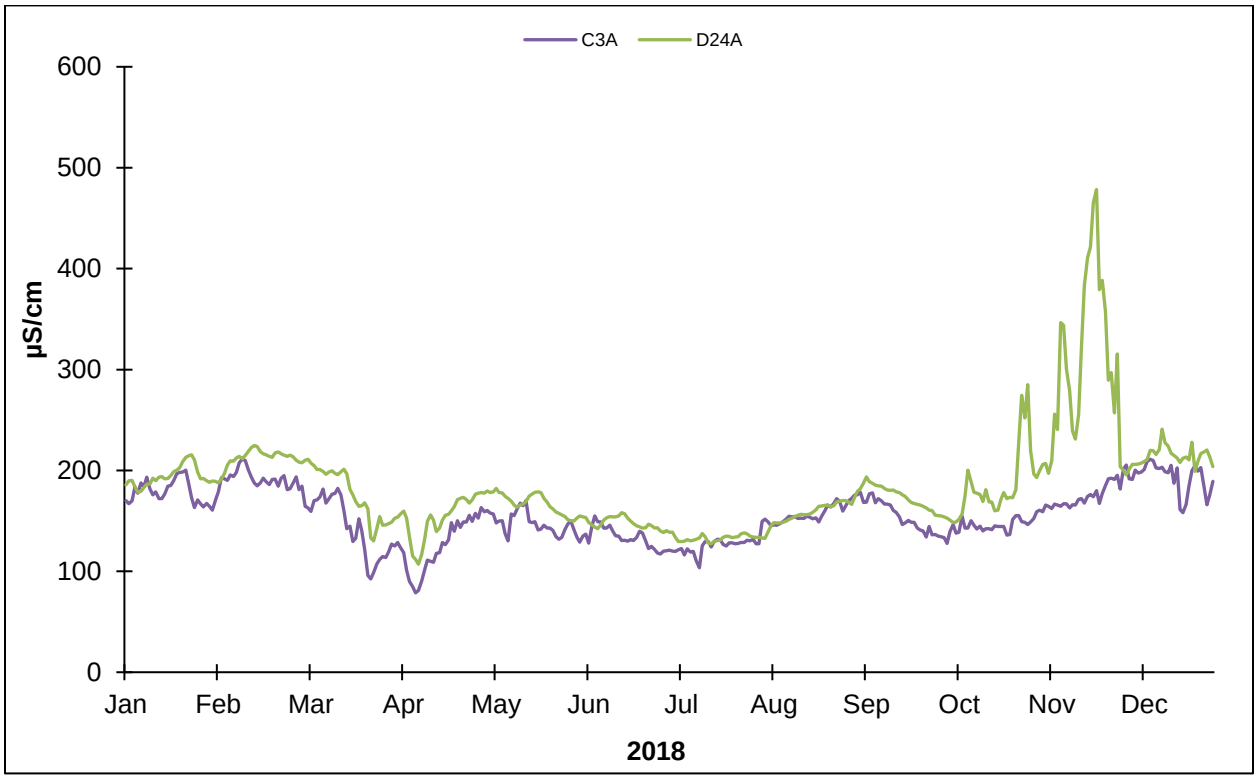

Figure 3b Average daily specific conductance Southern Interior Delta, 2018

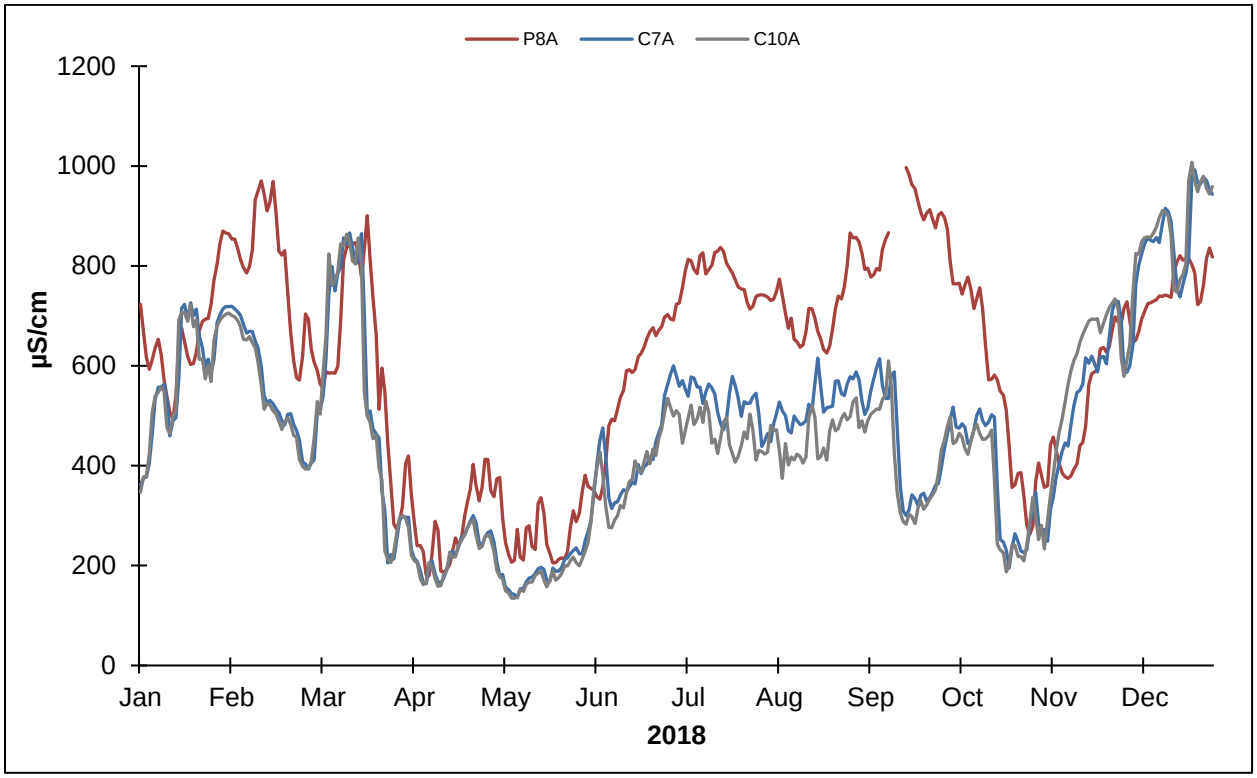

Figure 3c Average daily specific conductance Central Delta, 2018

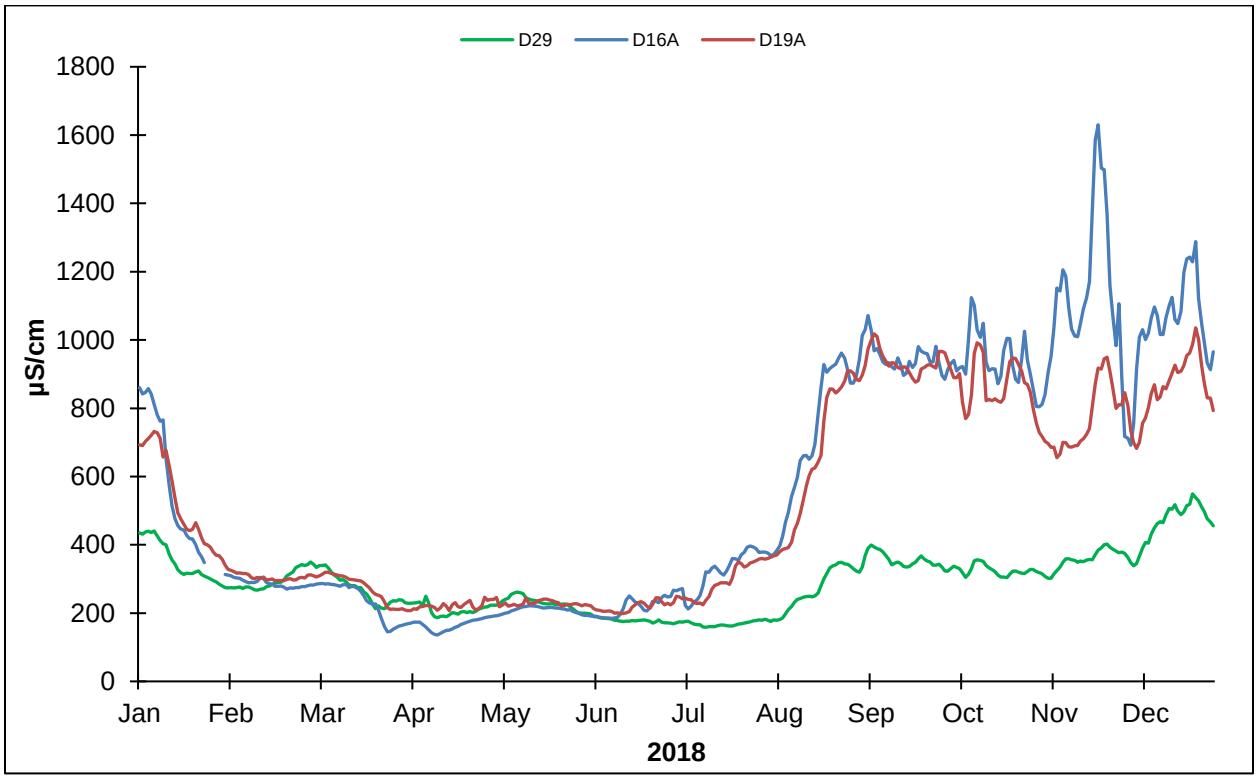

Figure 3d Average daily specific conductance Confluence, 2018

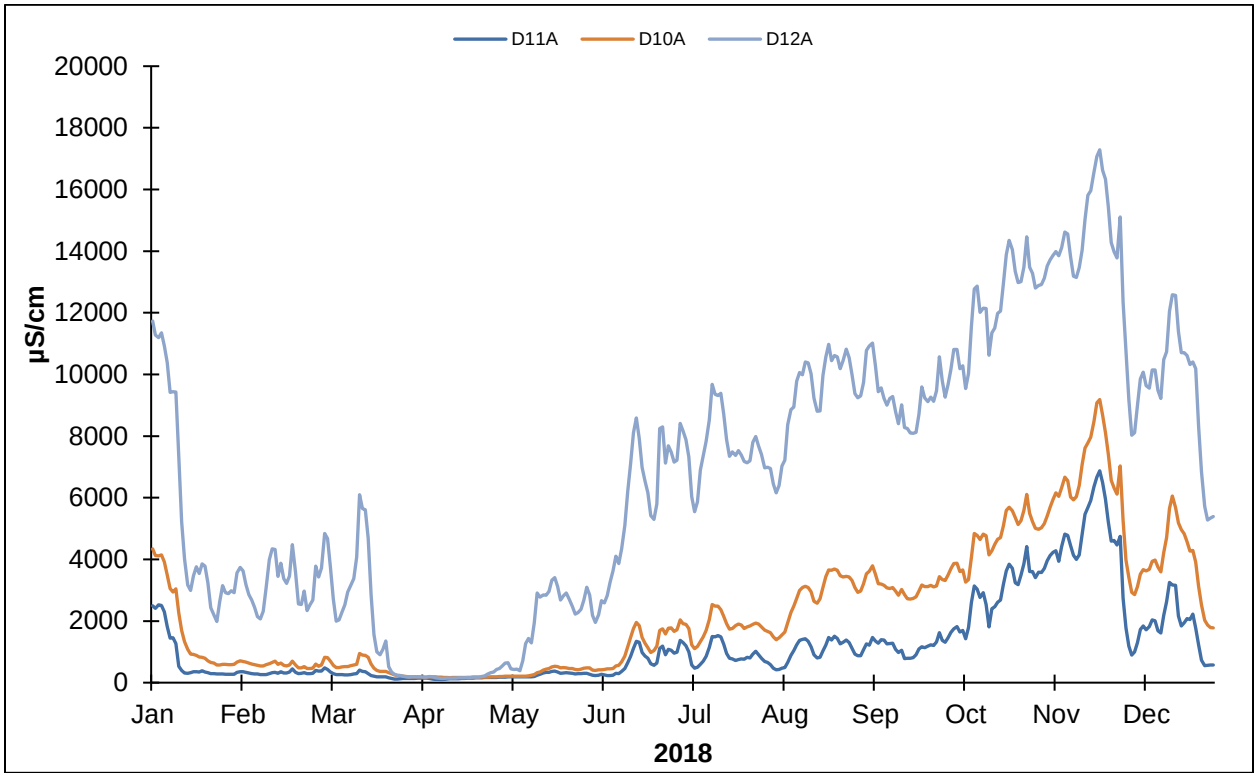

Figure 3e Average daily specific conductance Grizzly/Suisun Bay, 2018

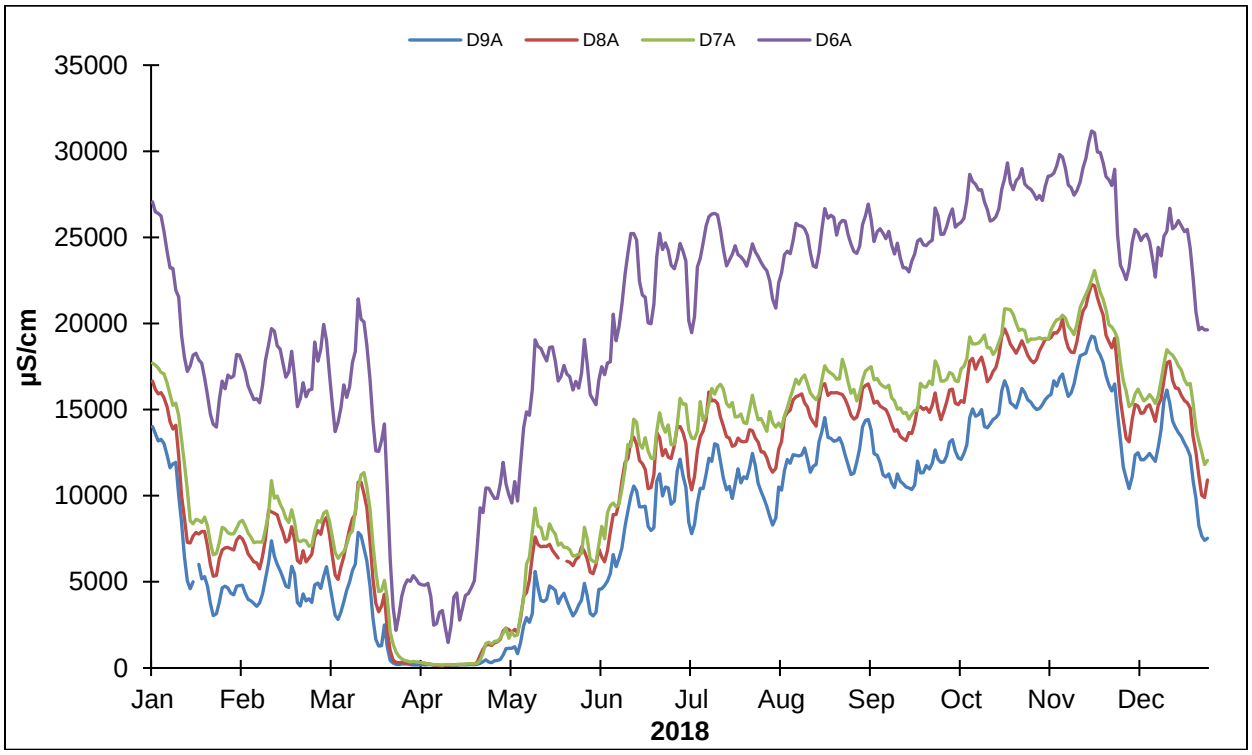

Figure 3f Average daily specific conductance Surface-Bottom, 2018

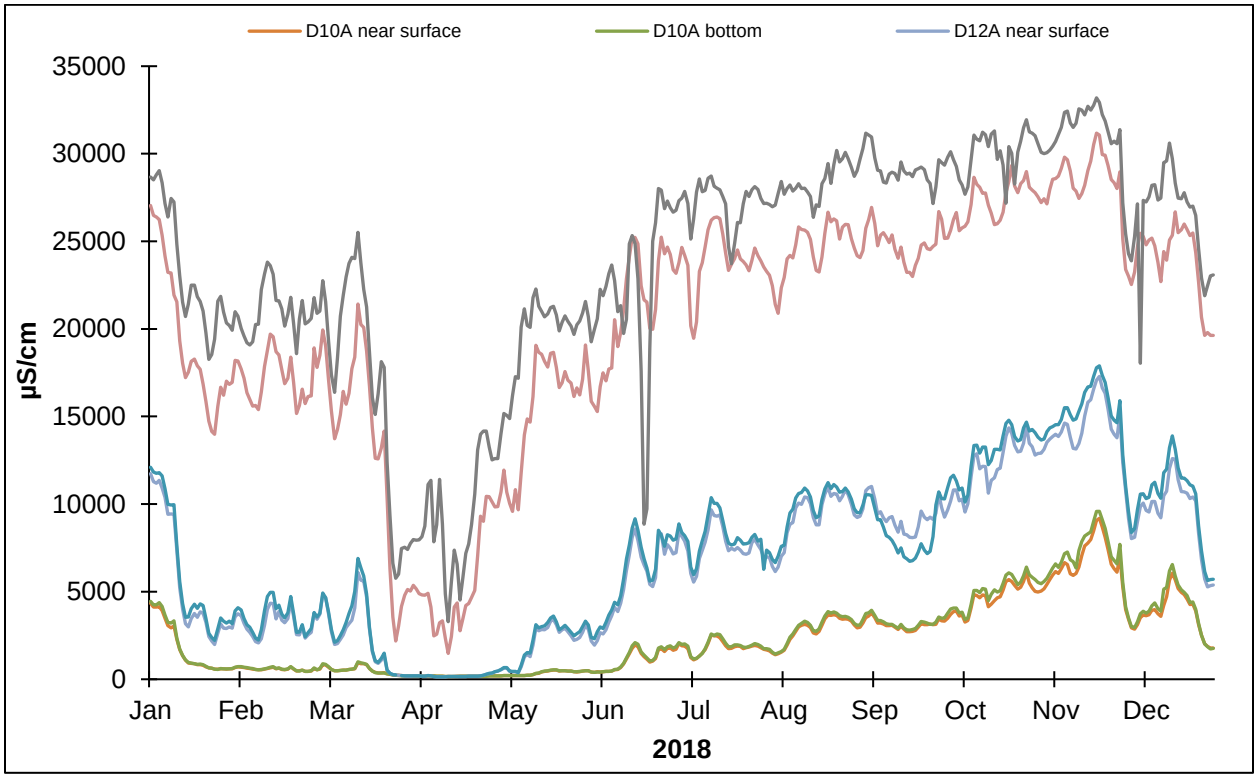

Figure 4a Average daily dissolved oxygen Northern Interior Delta, 2018

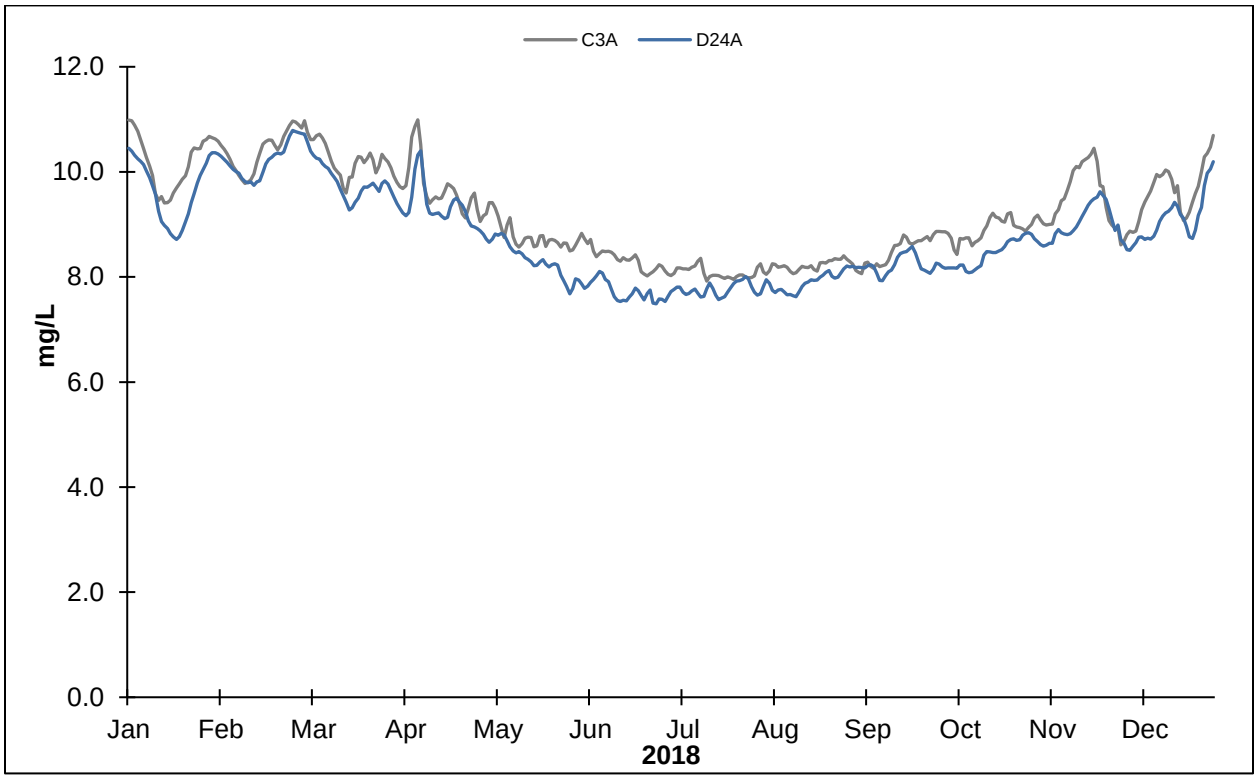

Figure 4b Average daily dissolved oxygen Southern Interior Delta, 2018

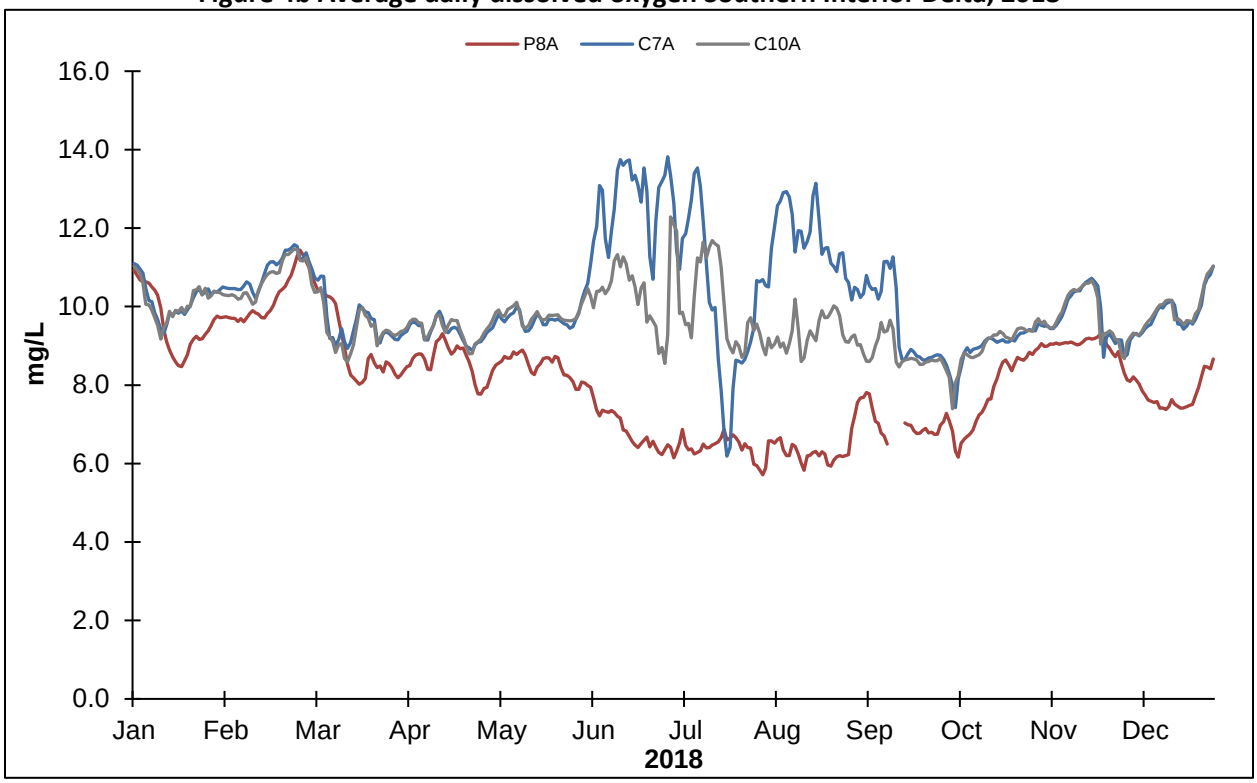

Figure 4c Average daily dissolved oxygen Central Delta, 2018

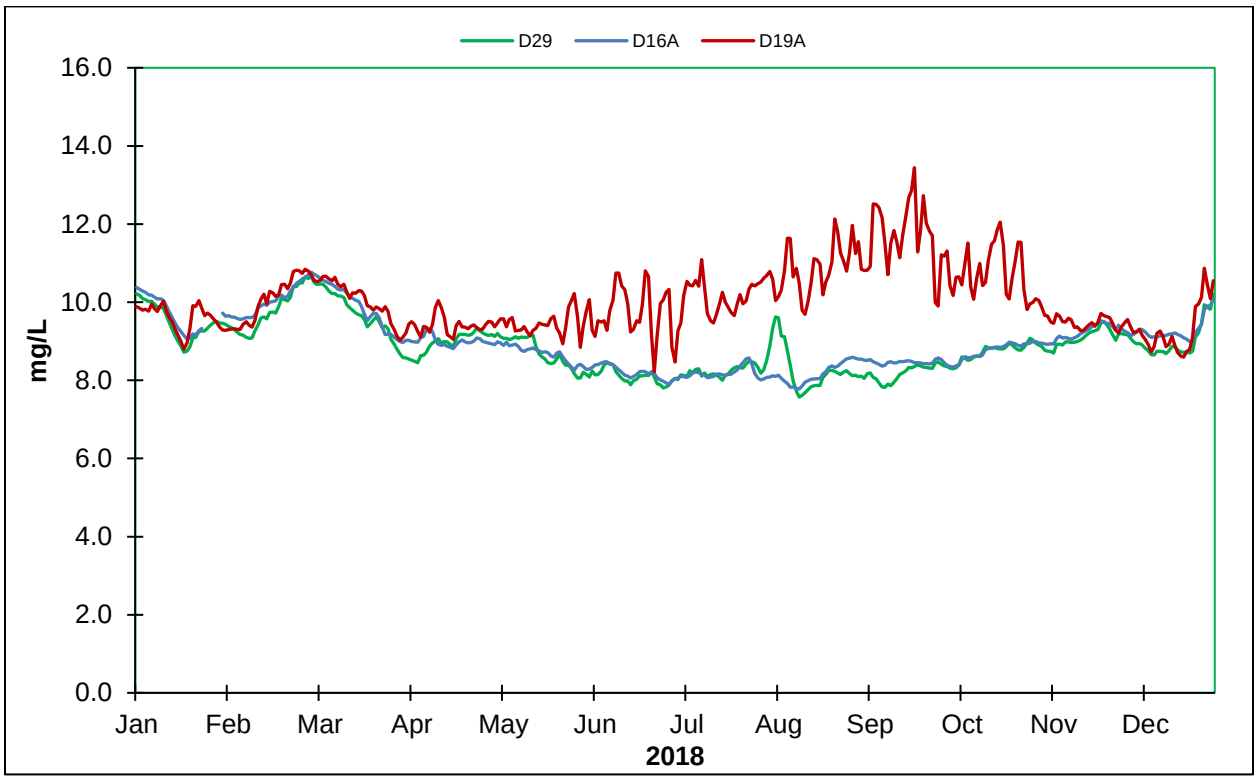

Figure 4d Average daily dissolved oxygen Confluence, 2018

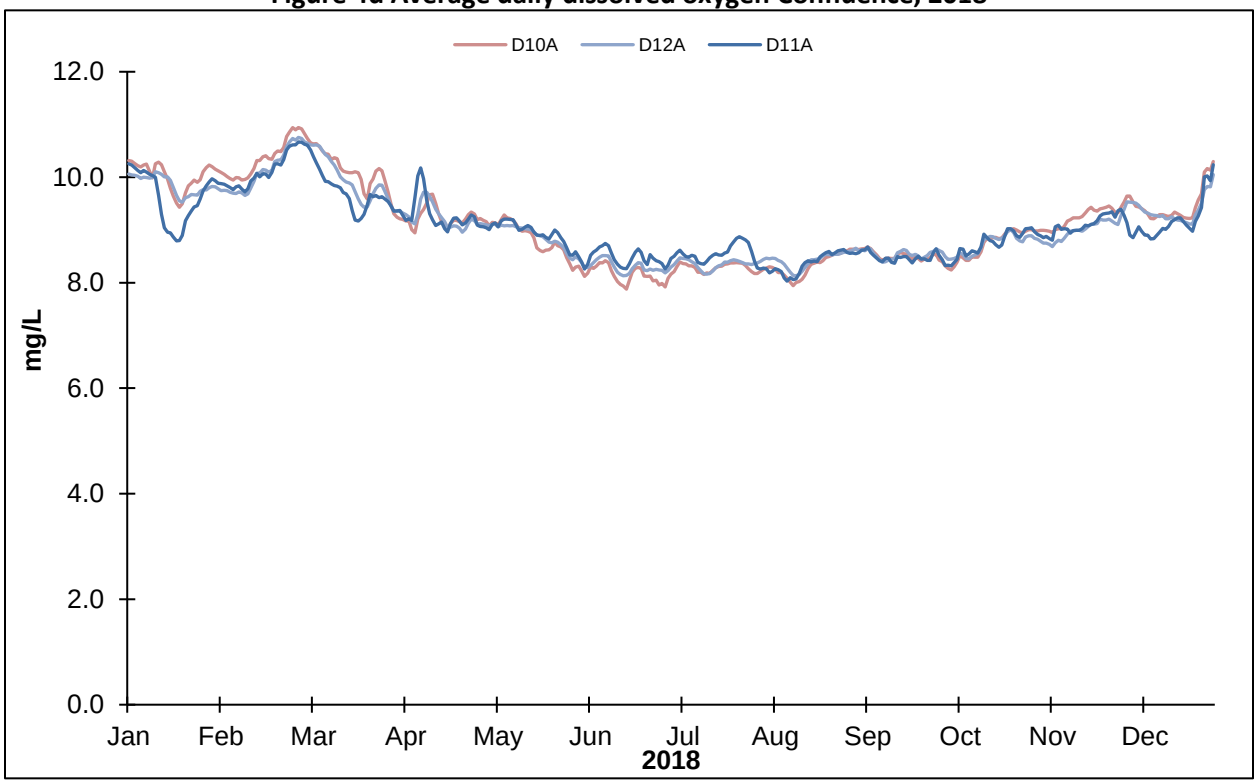

Figure 4e Average daily dissolved oxygen Grizzly/Suisun Bay, 2018

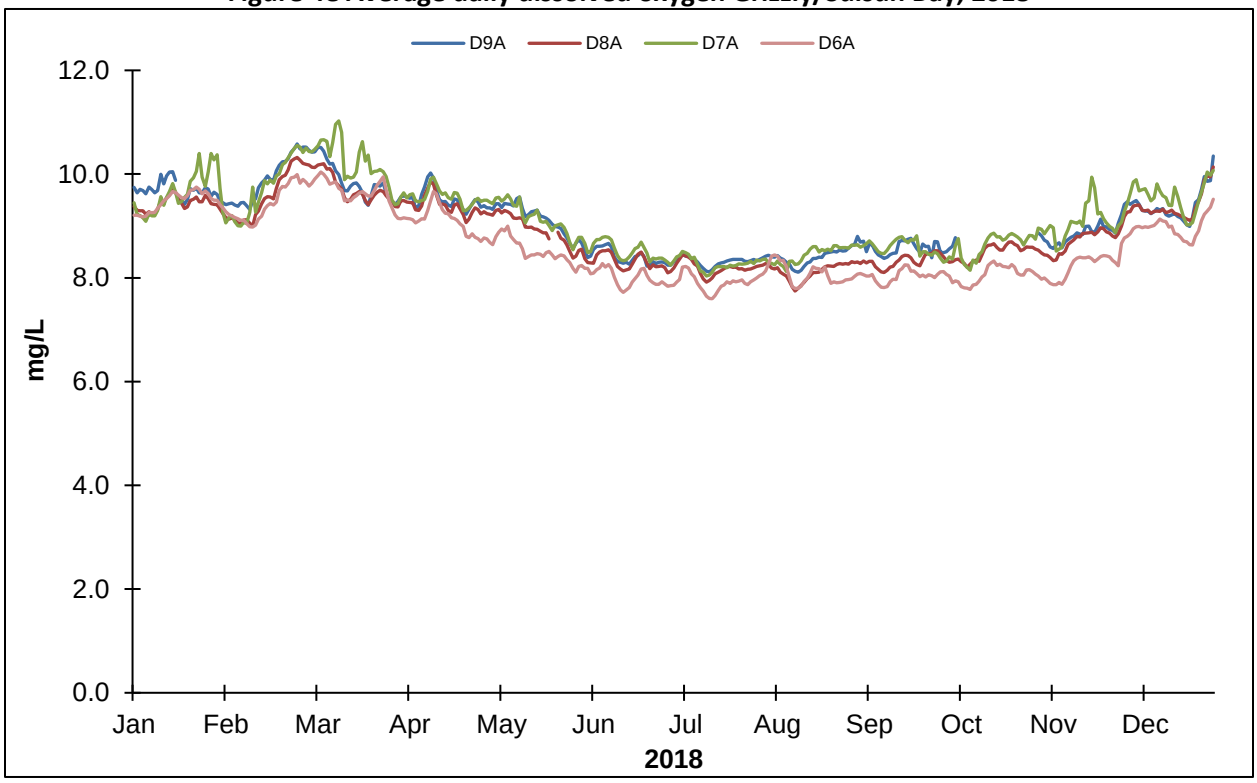

Figure 4f Range of daily dissolved oxygen Rough and Ready Isl. (P8), 2018

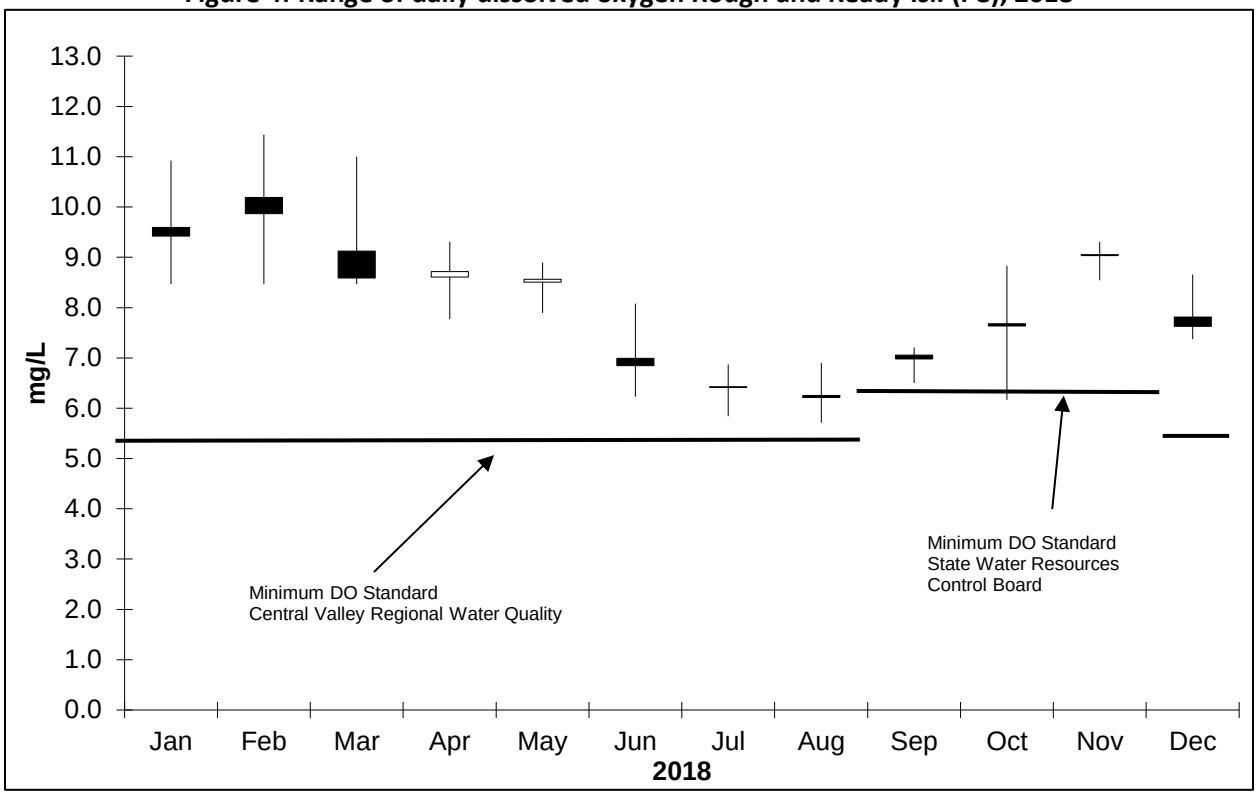

Figure 5a Average daily pH Northern Interior, 2018

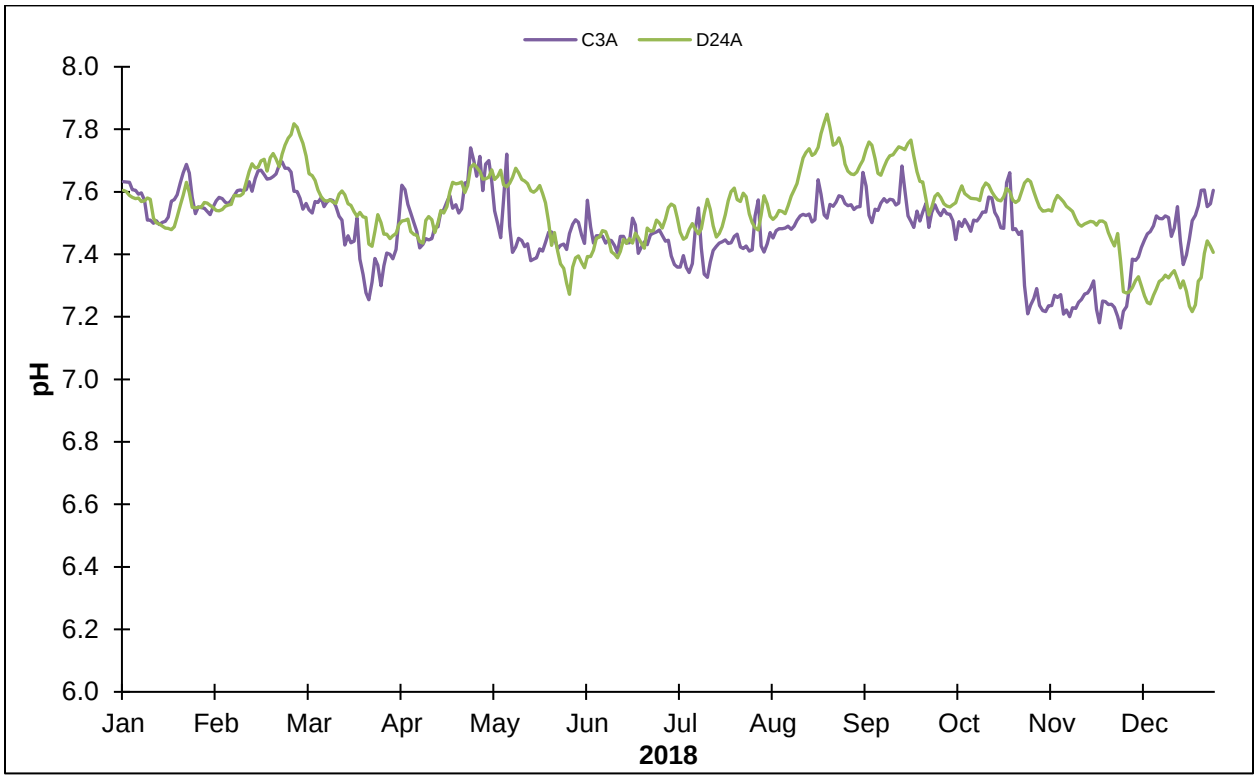

Figure 5b Average daily pH Southern Interior, 2018

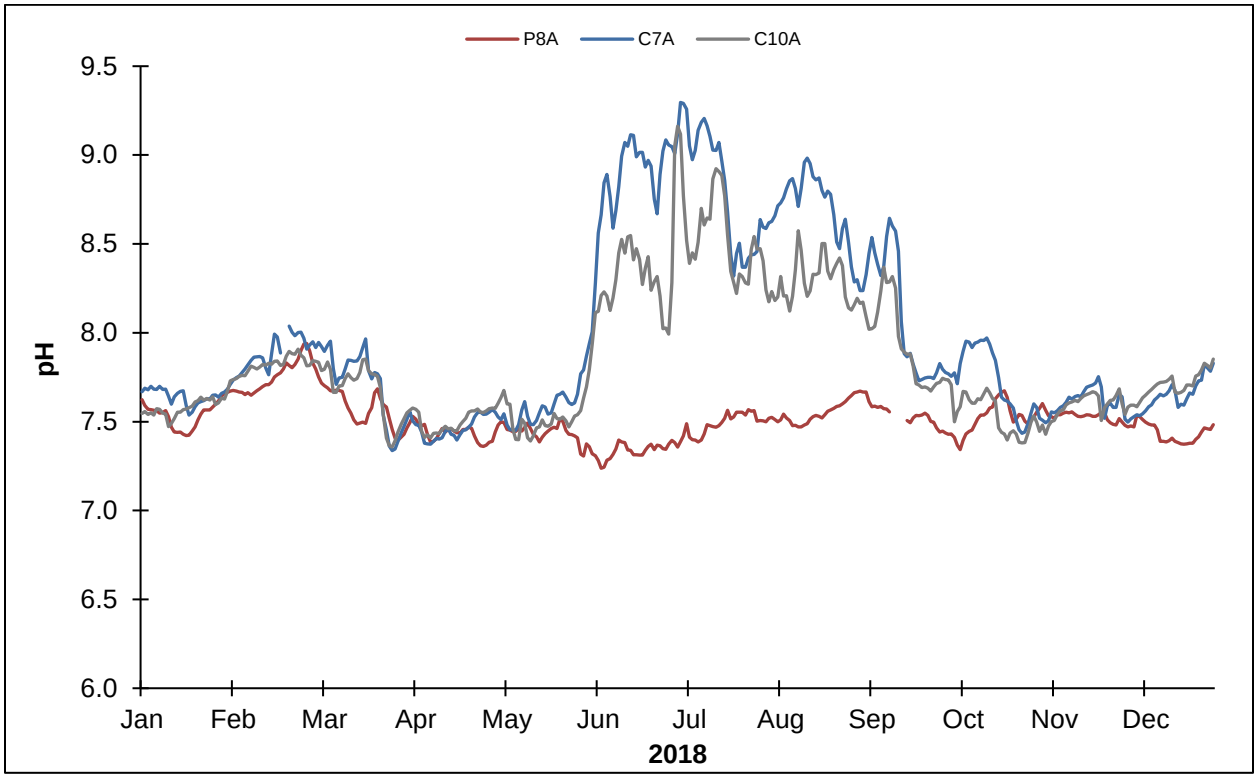

Figure 5c Average daily pH Central Delta, 2018

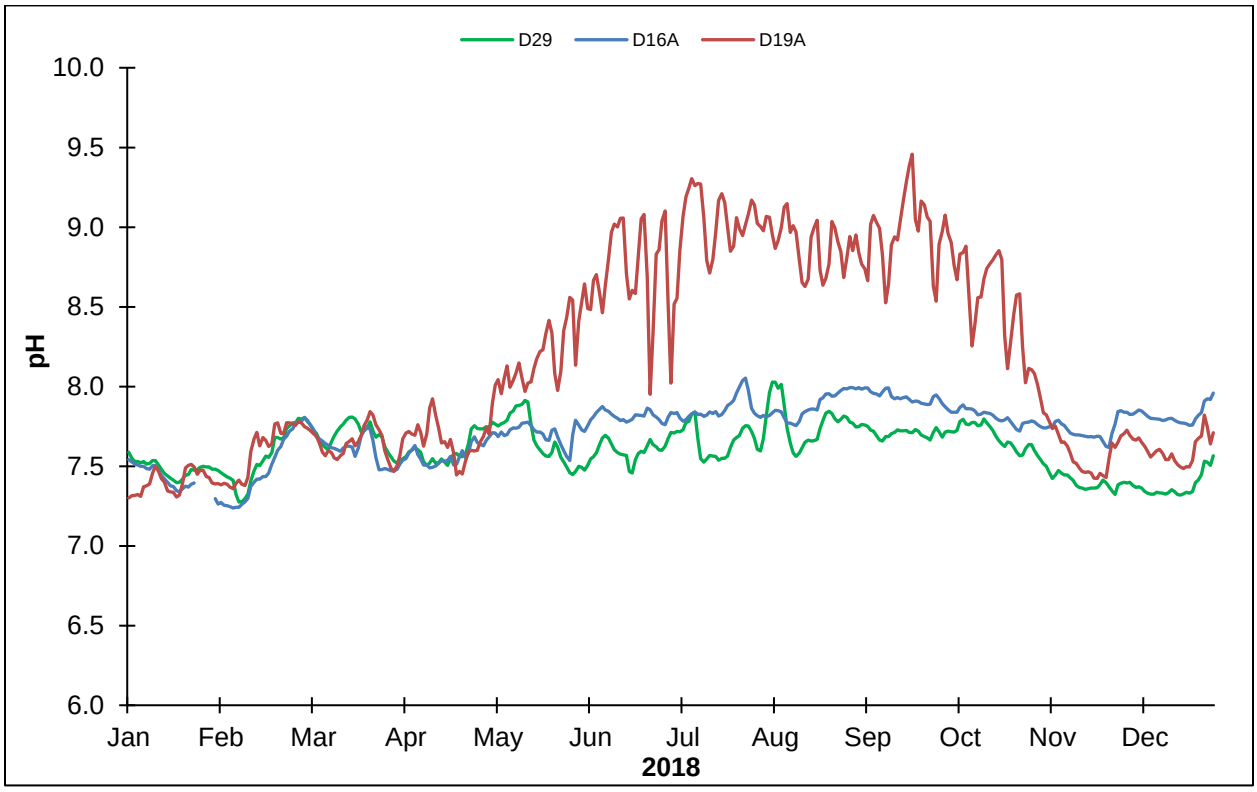

Figure 5d Average daily pH Confluence, 2018

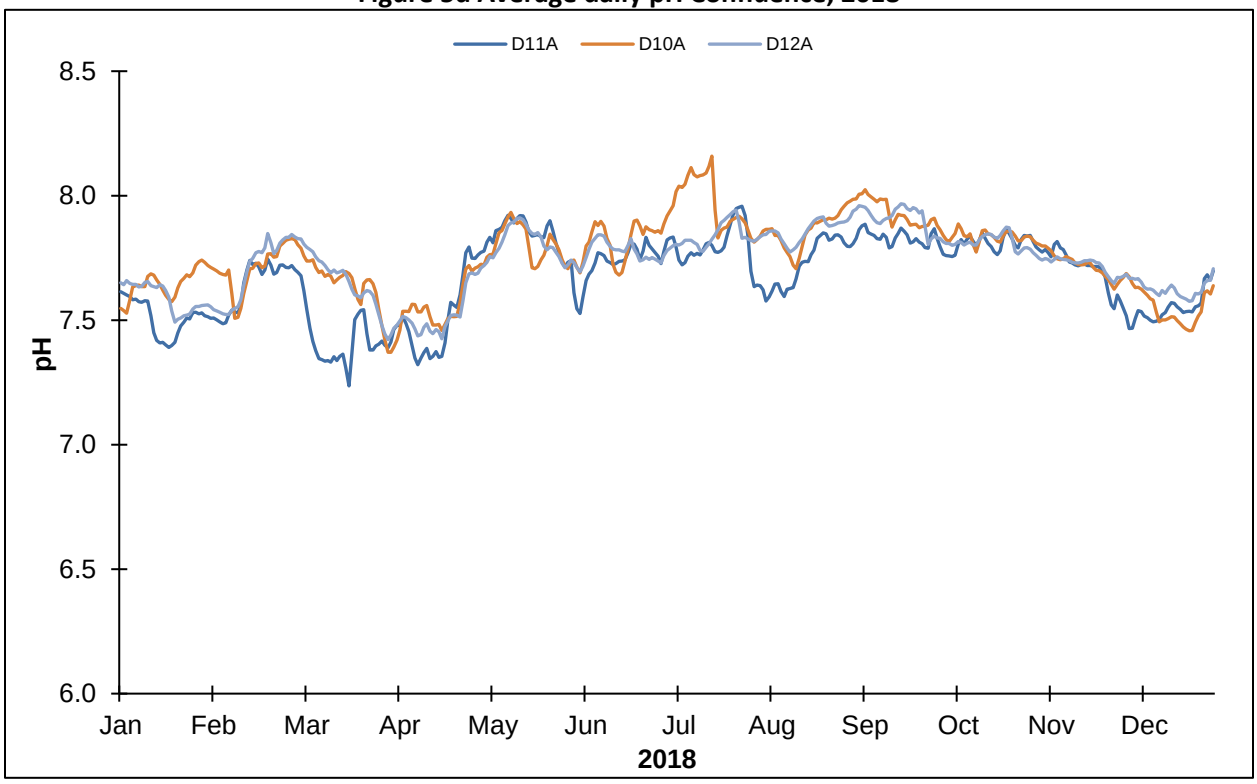

Figure 5e Average daily pH Grizzly/Suisun Bay, 2018

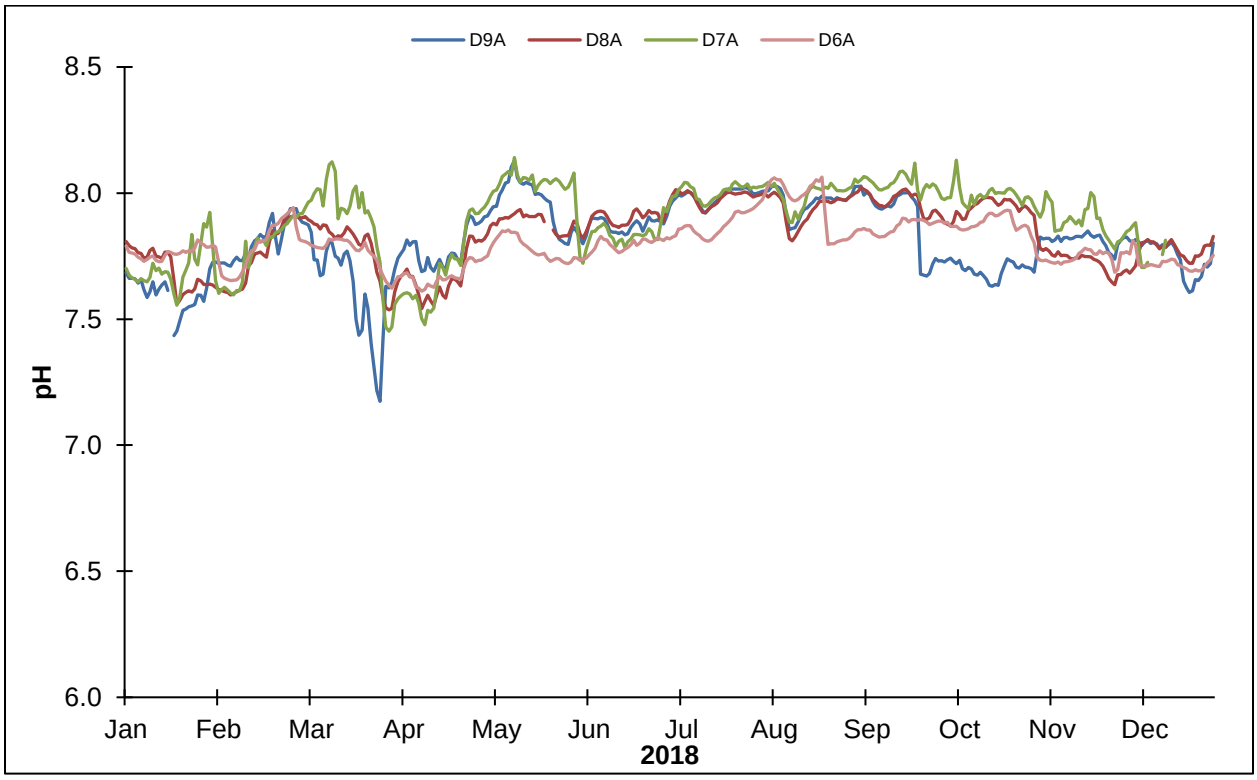

Figure 6a Average daily Turbidity Northern Interior Delta, 2018

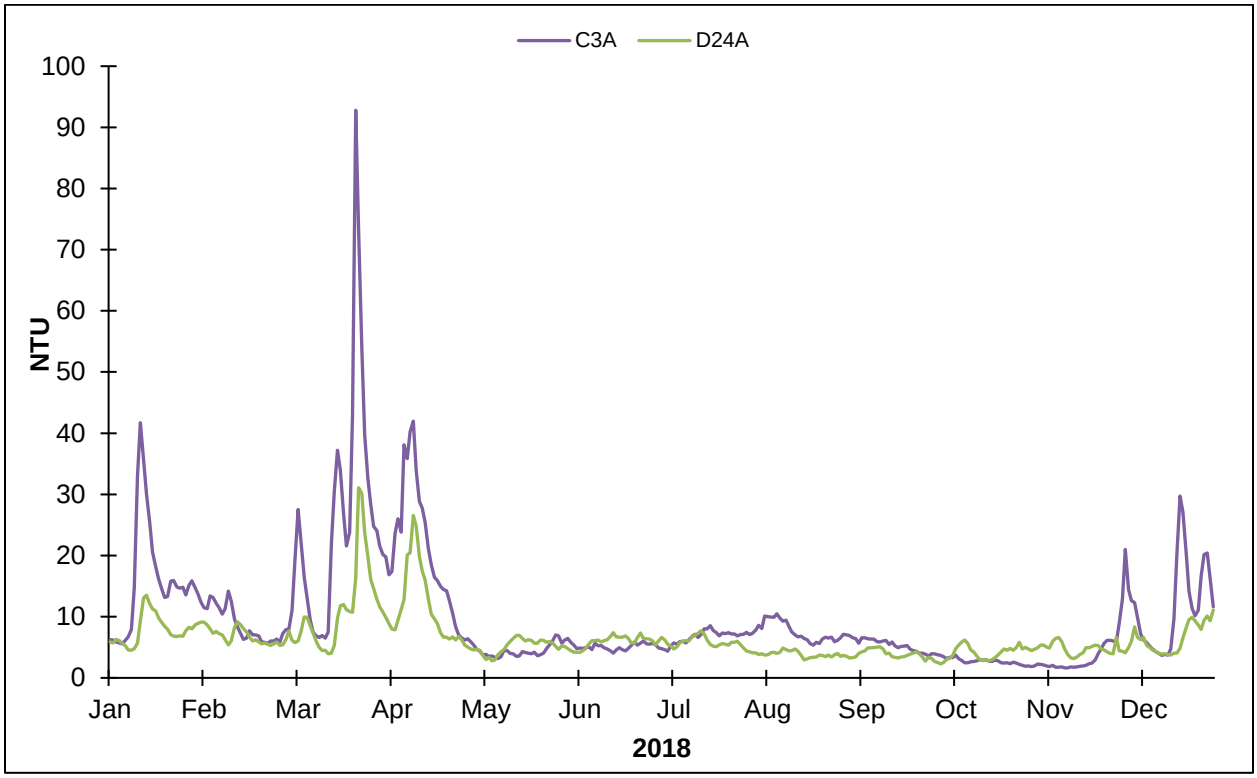

Figure 6b Average daily Turbidity Southern Interior Delta, 2018

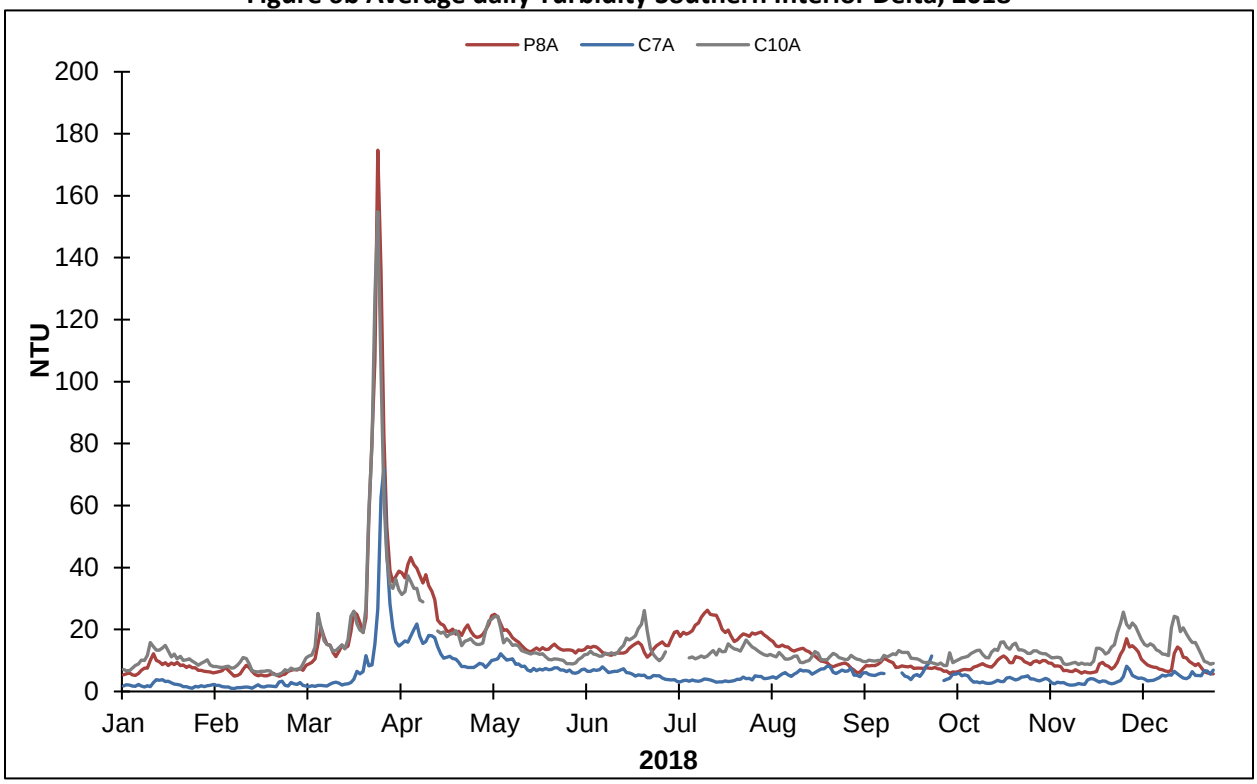

Figure 6c Average daily Turbidity Central Delta, 2018

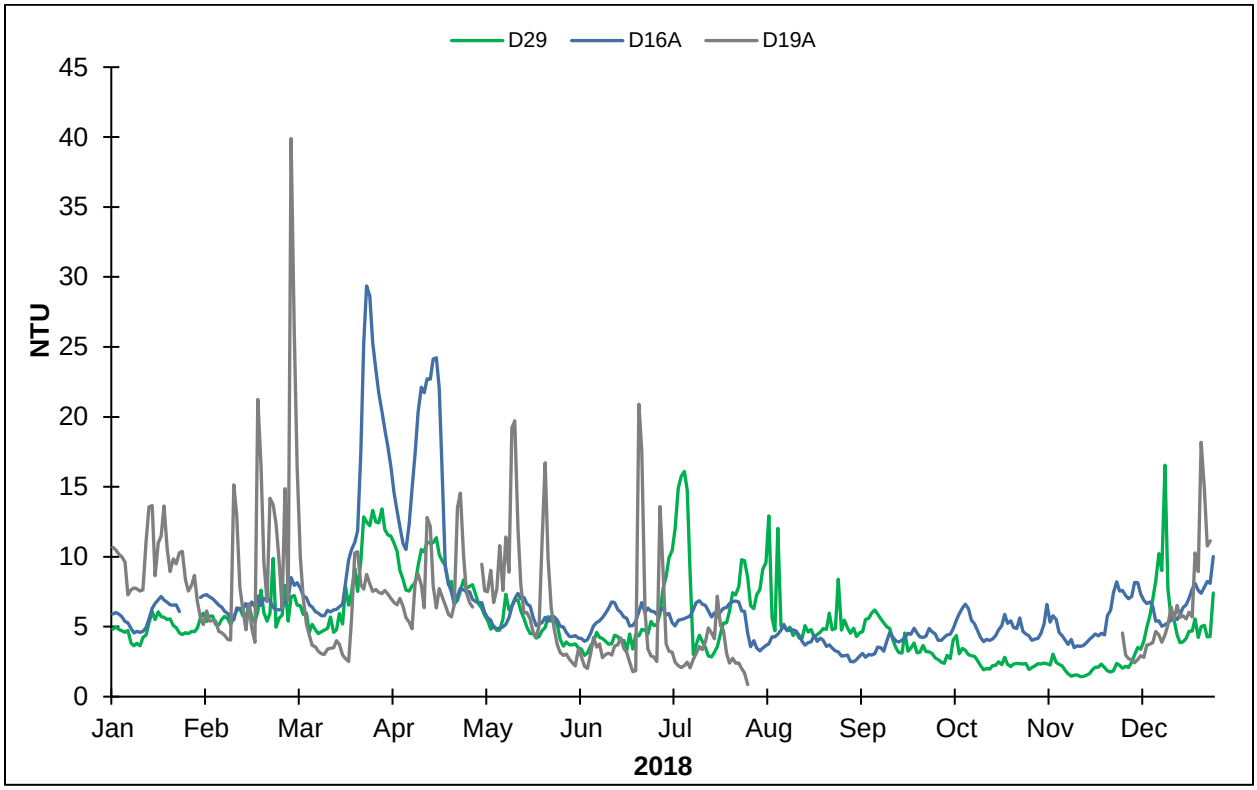

Figure 6d Average daily Turbidity Confluence, 2018

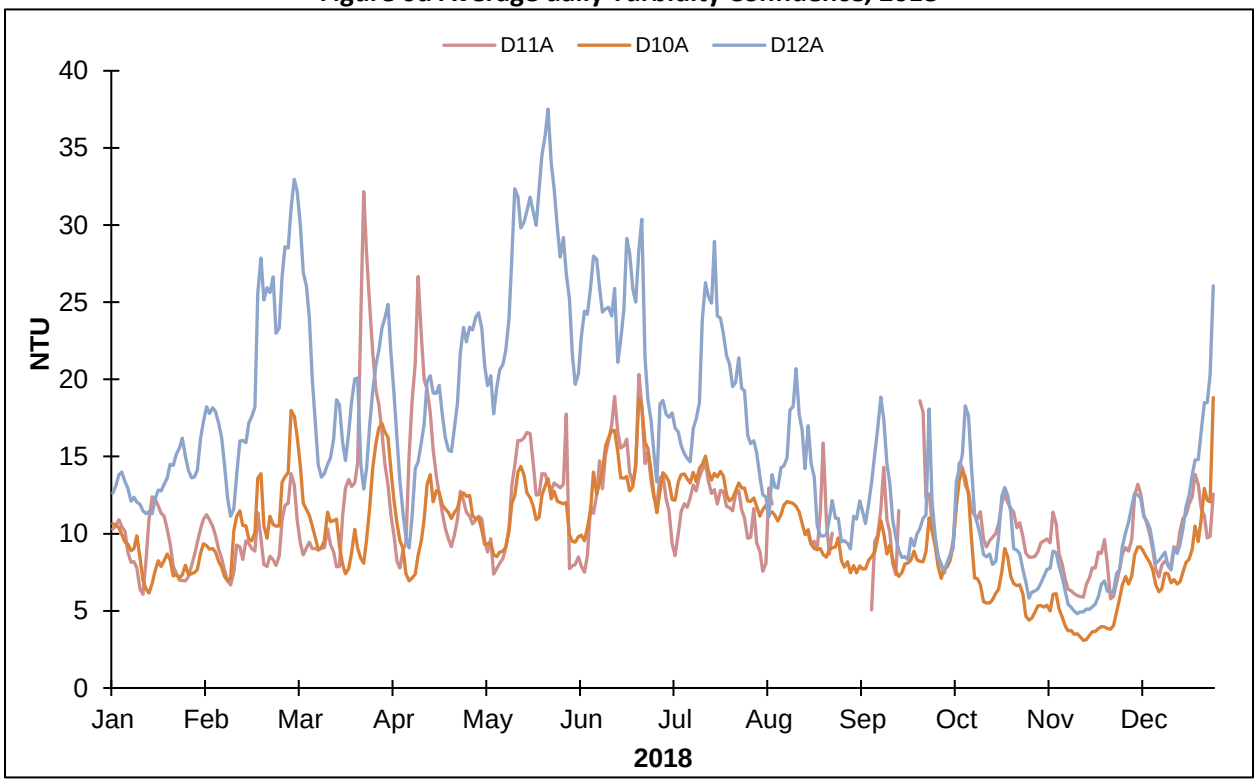

Figure 6e Average daily Turbidity Grizzly/Suisun Bay, 2018

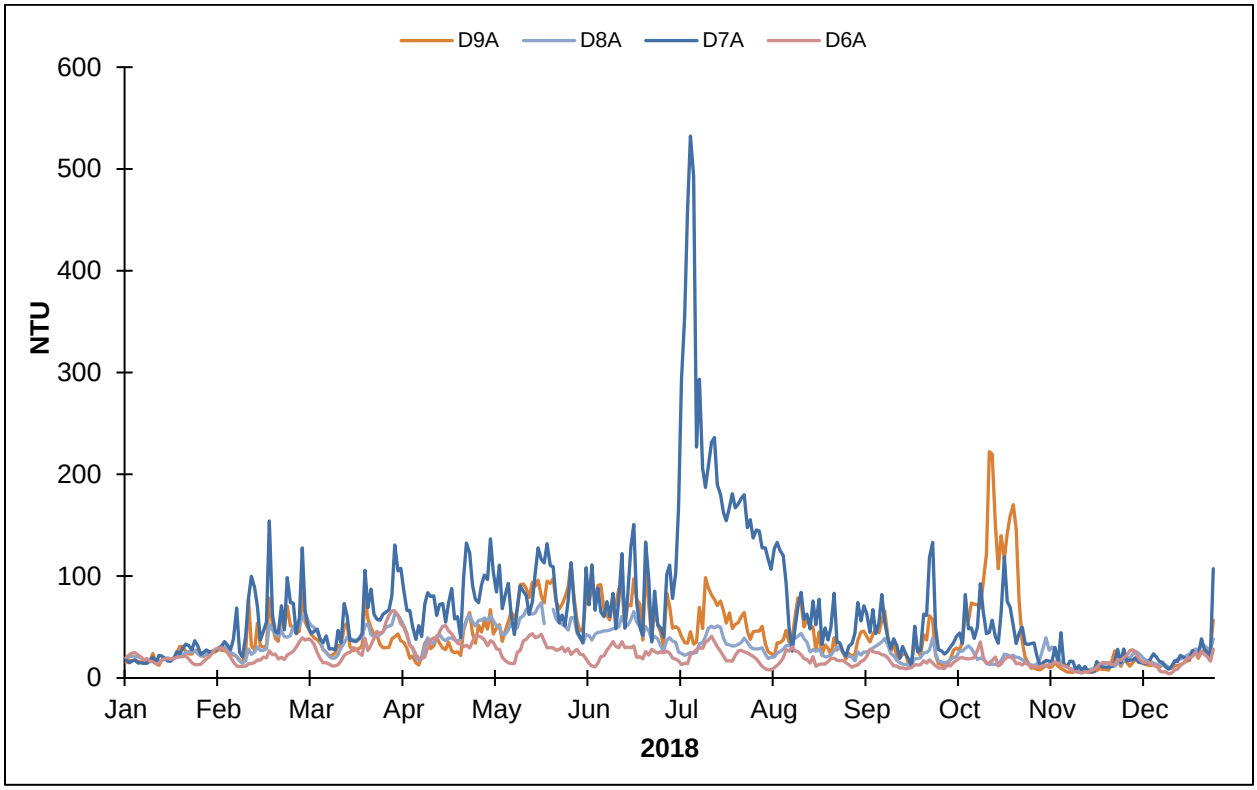

Figure 7a Average daily Fluorescence Northern Interior Delta, 2018

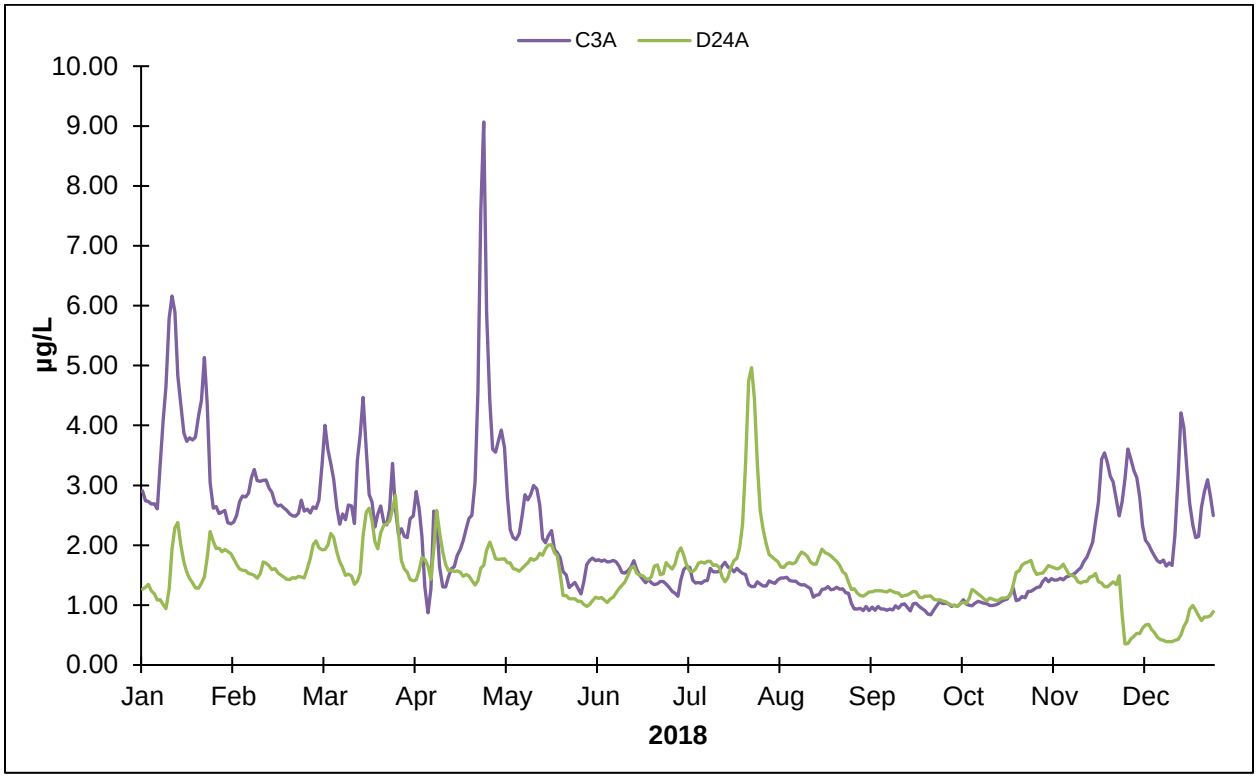

Figure 7b Average daily Fluorescence Southern Interior Delta, 2018

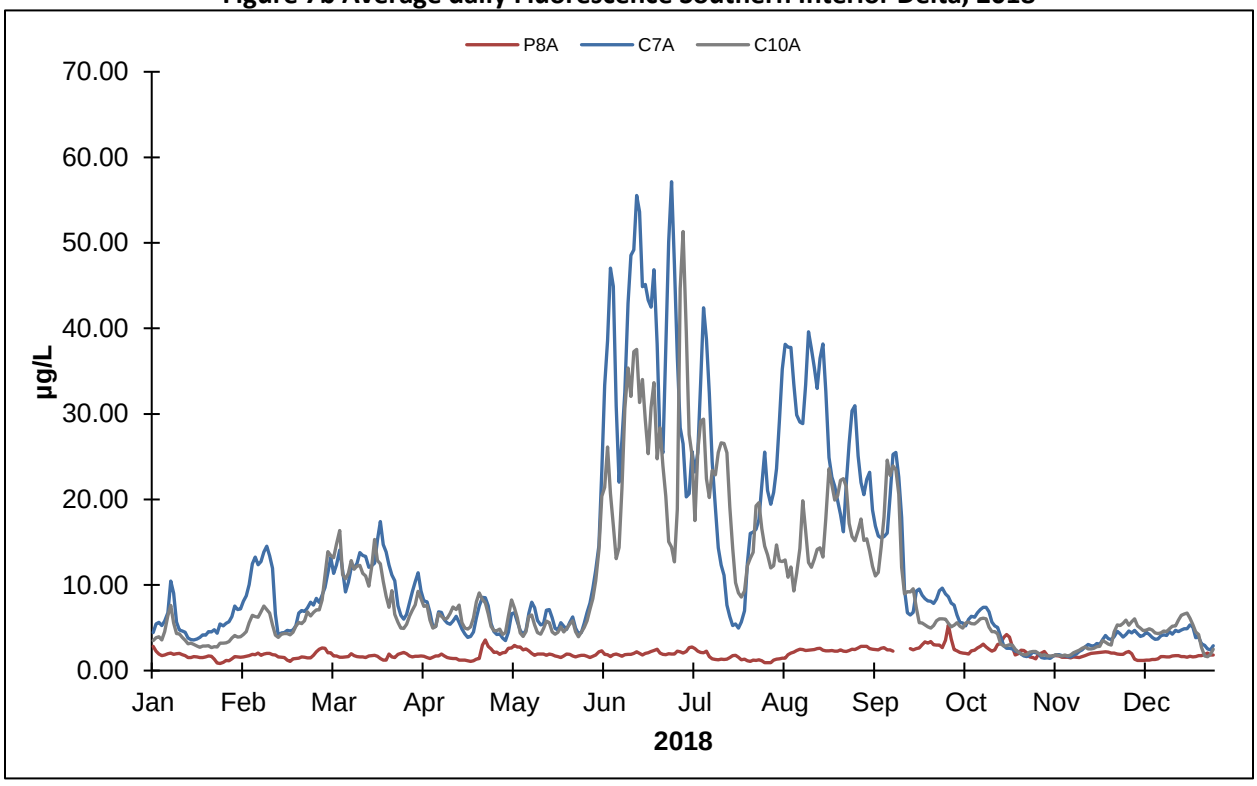

Figure 7c Average daily Fluorescence Central Delta, 2018

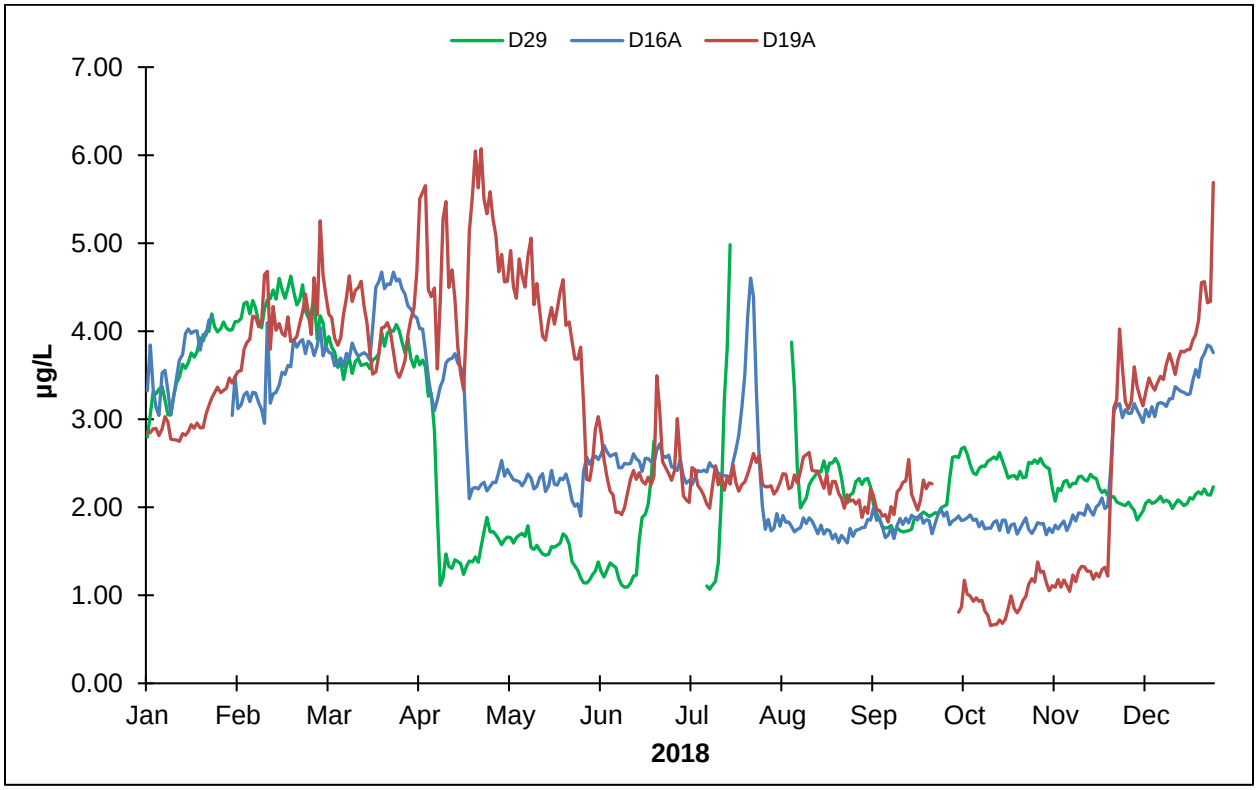

Figure 7d Average daily Fluorescence Confluence, 2018

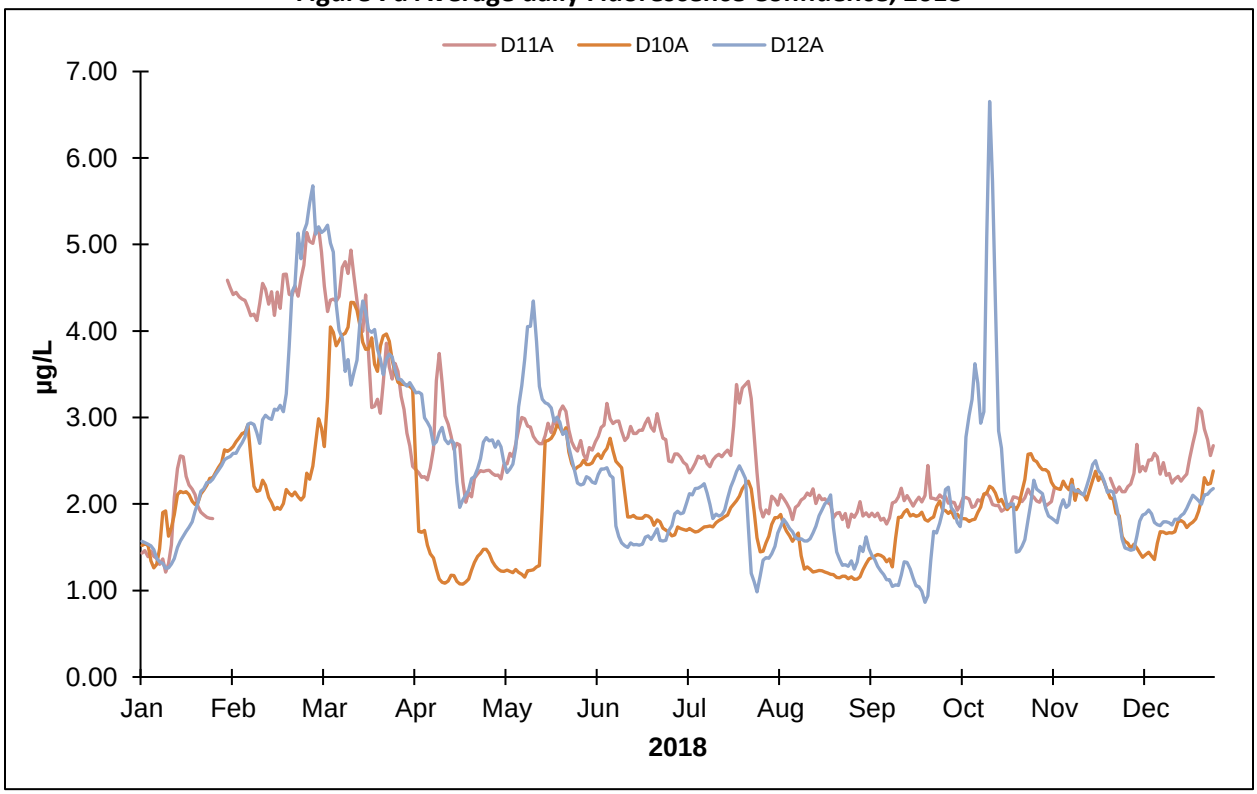

Figure 7e Average daily Fluorescence Grizzly/Suisun Bay, 2018

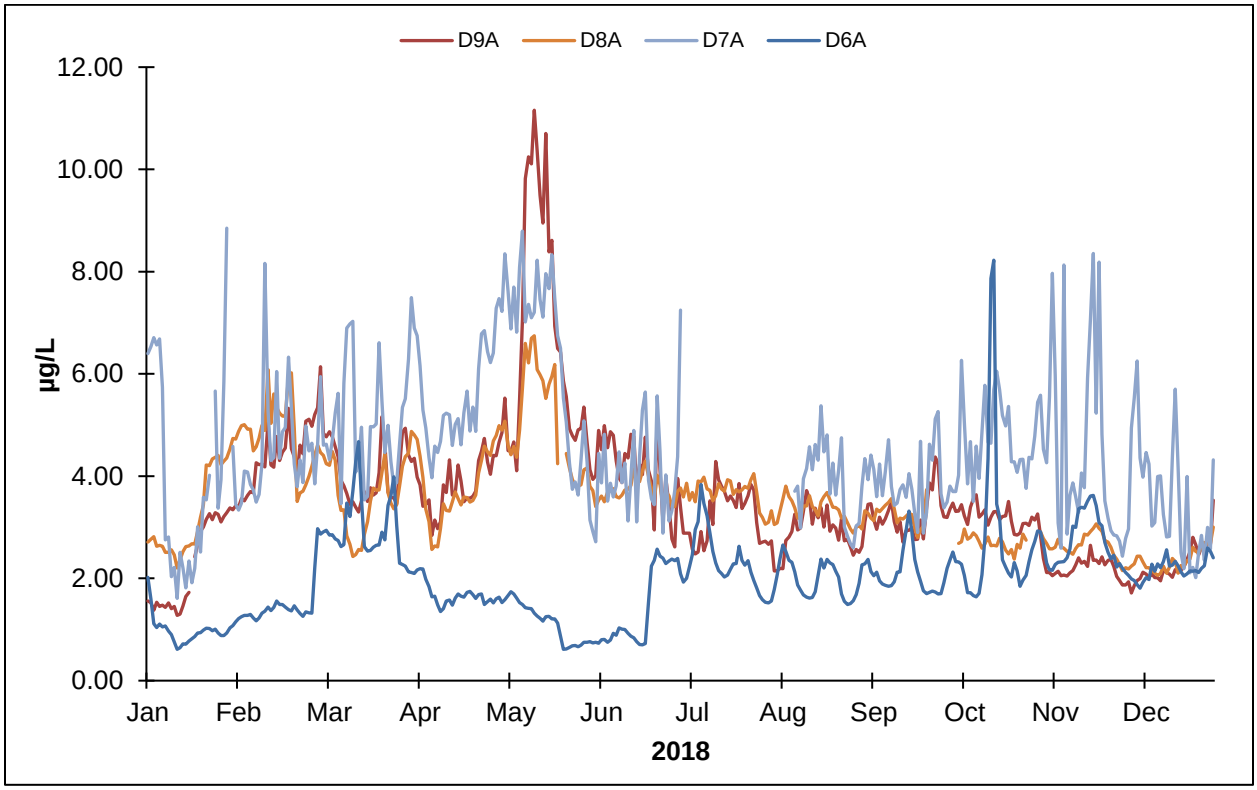

Table 2 - Parameters

Parameter	***Units***	***Frequency***
Water Temperature	°C	15-minute instantaneous
Specific Conductance	µS/cm	15-minute instantaneous
DO	mg/L	15-minute instantaneous
pH	unitless	15-minute instantaneous
Turbidity	NTU	15-minute instantaneous
Fluorescence	µg/L	15-minute instantaneous