Morro Bay Watershed Creek Health
For Water Year 2018

Date Range: October 1, 2017 to September 30, 2018
Analytes: Dissolved oxygen, water temperature, nitrates as nitrogen, orthophosphates as phosphorus

Background

The Morro Bay National Estuary Program's Monitoring Program conducts monitoring in the Morro Bay estuary and watershed to track ambient water quality trends and to assess the impacts of specific implementation projects.

Monitoring data is collected by Estuary Program staff and volunteers, under the guidance of a Quality Assurance Project Plan (QAPP) which is reviewed and approved by EPA and the Central Coast Regional Water Quality Control Board (CCRWQCB). This document contains the monitoring locations, protocols, equipment specifications, and other details that allow users to assess the quality of the collected data. The full document is available upon request.

Creek Oxygen and Water Temperature

The Estuary Program wanted to be able to assess how often local creeks had water quality conditions that were supportive of sensitive wildlife such as steelhead during water year (WY) 2018.

Equipment Specification: The Estuary Program deploys the HOBO Dissolved Oxygen Data Logger, part Number U26-001. These continuous monitoring meters were deployed for two weeks at a time to assess diurnal cycles in dissolved oxygen concentration (in mg/L) and water temperature (in °C). The second week of these deployments sometimes yielded poor results for dissolved oxygen data, while temperature data remained accurate throughout. Thus, for this report, the first week of dissolved oxygen data was kept for analysis and the second week was excluded while both weeks of temperature data was included. The equipment specifications are as follows:

Dissolved Oxygen (DO) Concentration

Specification	Value
Sensor Type	Optical
Measurement Range	0 to 30 mg/L
Calibrated Range	0 to 20 mg/L; 0 to 35°C
Accuracy	+/- 0.2 mg/L up to 8 mg/L, +/- 0.5 mg/L from 8 to 20 mg/L
Resolution	0.02 mg/L

The DO data from CCC was consistent with historic data and with expected environmental trends (i.e., diurnal cycles, seasonal changes, etc.), whereas the sensor deployed at UCR experienced erratic measurements that could not explained by environmental conditions. Thus, dissolved oxygen data from UCR was not included in this report.

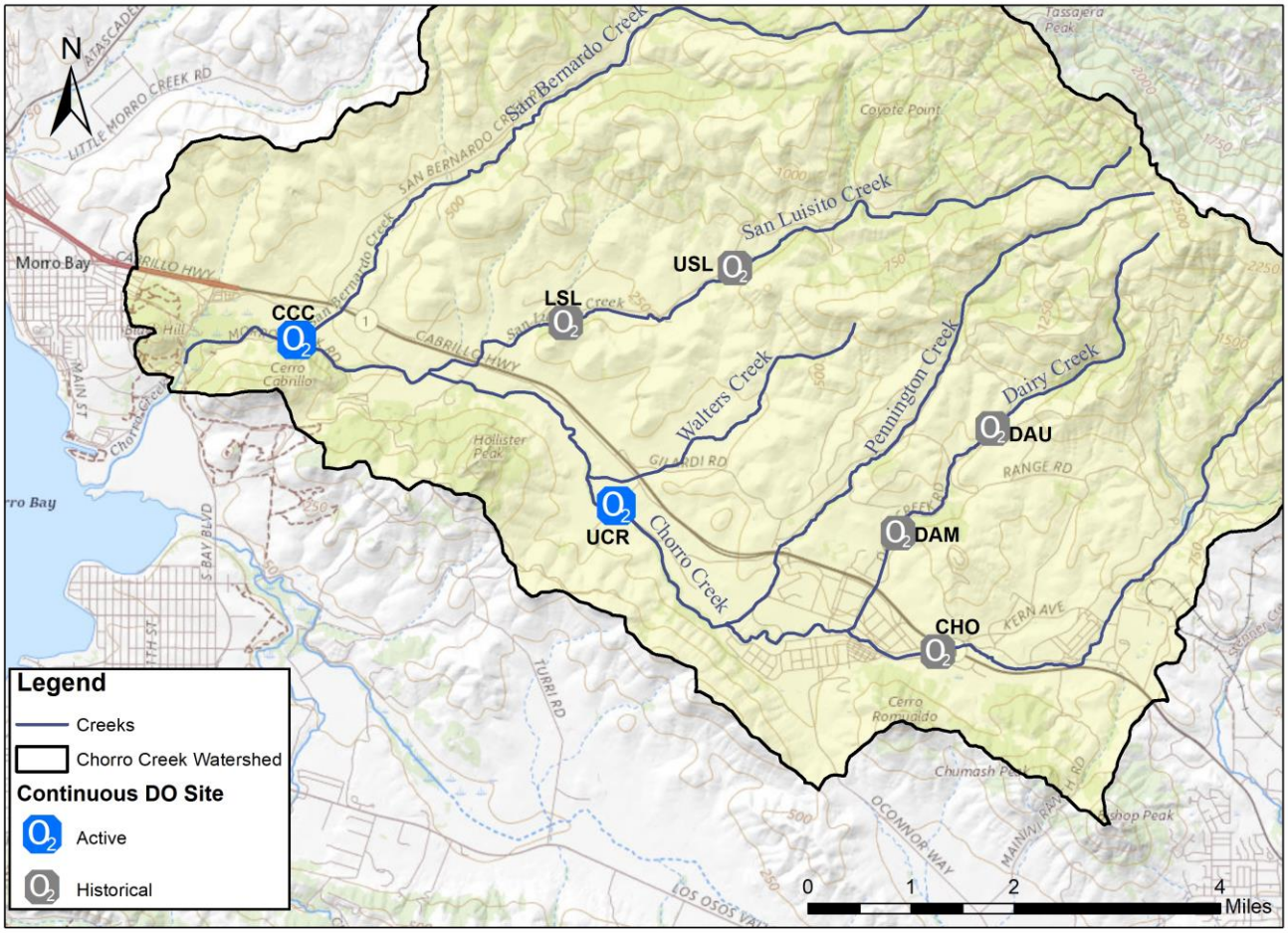
Water Temperature

Specification	Value
Temperature Measurement/Operating Range	-5 to 40°C
Temperature Accuracy	+/- 0.2°C
Temperature Resolution	0.02°C

The HOBO meters are calibrated at the start of each deployment by placing them in a water-saturated air environment and using the manufacturer's calibration software. A second dissolved oxygen meter is used to collect DO and temperature readings at the beginning and end of the deployment that correct for normal sensor drift. The DO sensor cap is replaced every six months, and it automatically expires seven months after initialization.

Monitoring Locations: The sensors are deployed in pairs to obtain upstream/downstream sets of data. During WY 2018, they were deployed in pairs on Chorro Creek. The Chorro Creek sites were selected because Chorro Creek is known to support sensitive steelhead.

Chorro Creek Continuous Dissolved Oxygen Monitoring - Present and Historic



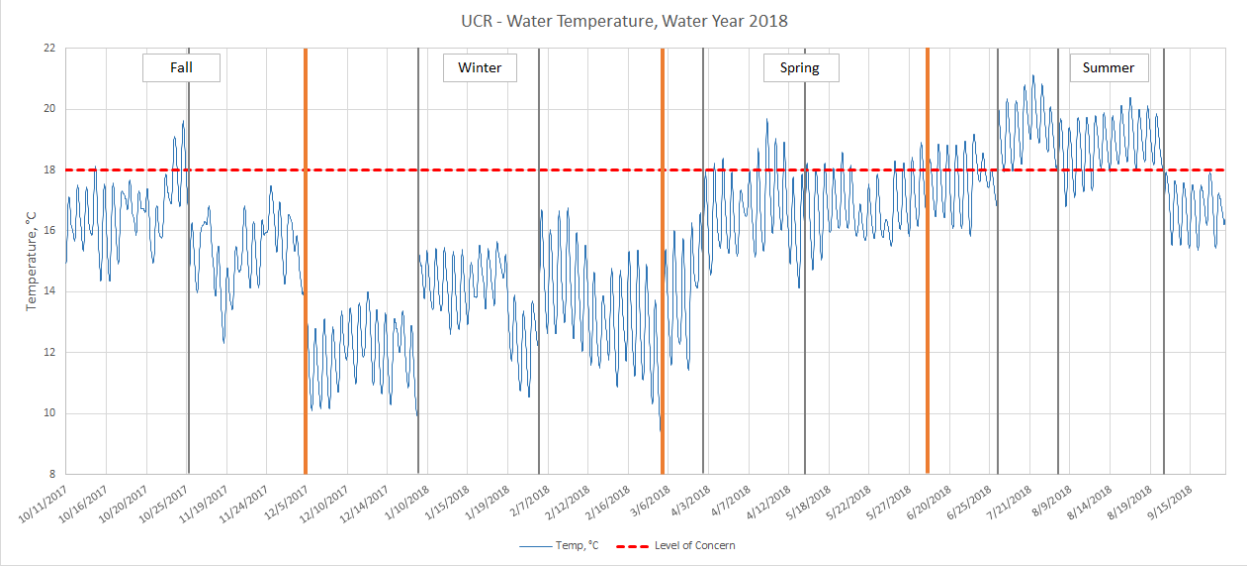
Results:

Temperature

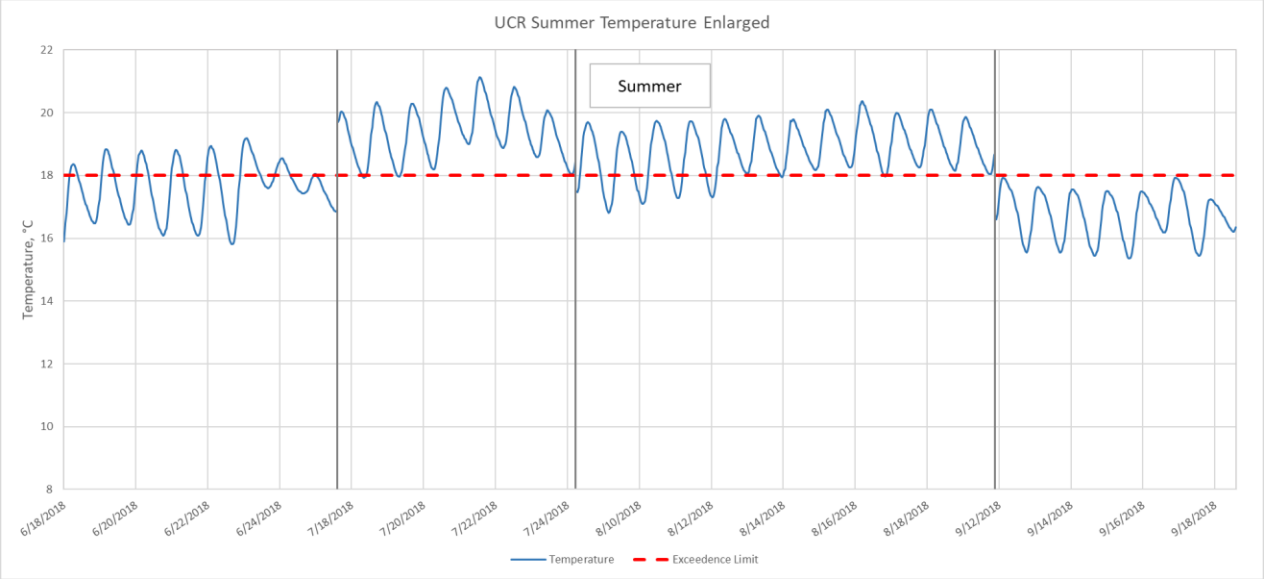
Continuous temperature data is of value because it shows the time of day and duration of elevated temperatures. We wanted to determine how often and for how long temperatures were greater than 18°C, a level protective of sensitive fish such as steelhead.

The following graphs show temperatures at Chorro Creek Road (site code CCC) and at Upper Chorro Reserve (UCR) on Chorro Creek. UCR is located downstream of the California Men's Colony (CMC) Wastewater Treatment Plant (WWTP) outfall into Chorro Creek. CCC is near the bottom of Chorro Creek, just upstream of Chorro Flats. The presence of steelhead has been confirmed at both locations in recent years.

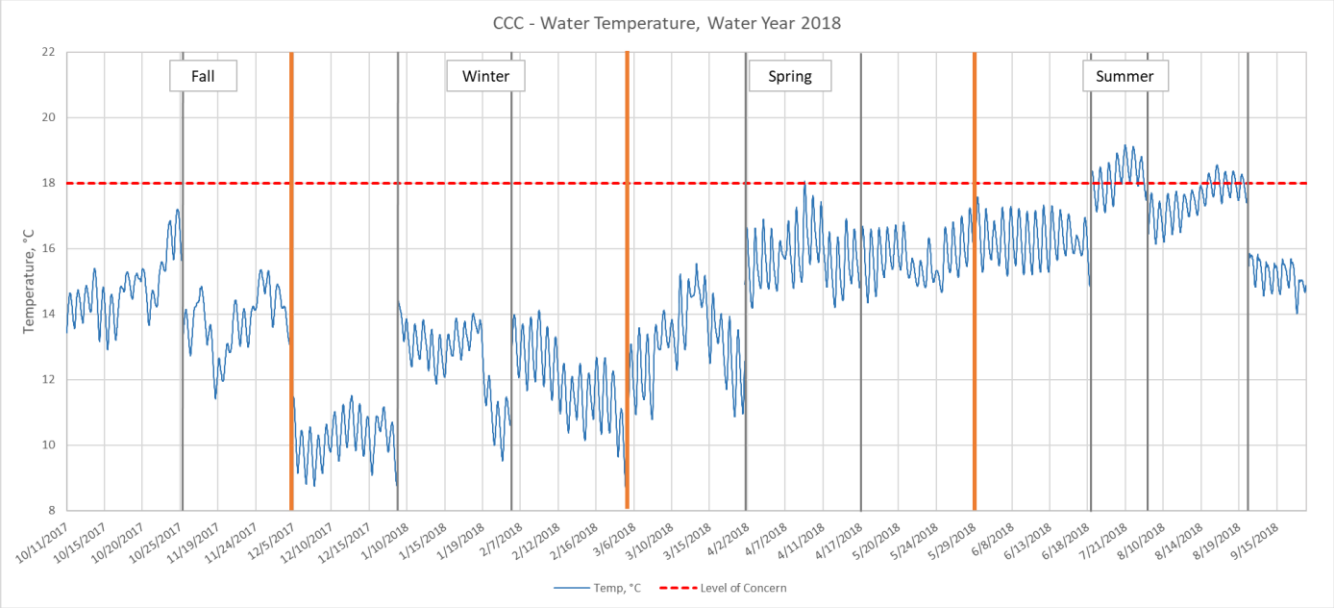
Also note that we have extended the duration of the summer data collection season to the end of September to compensate for the early fall cut-off that occurs in the water year. In the graphs below, the orange vertical bars represent seasonal divisions in data, and the gray bars represent separate sensor deployments.



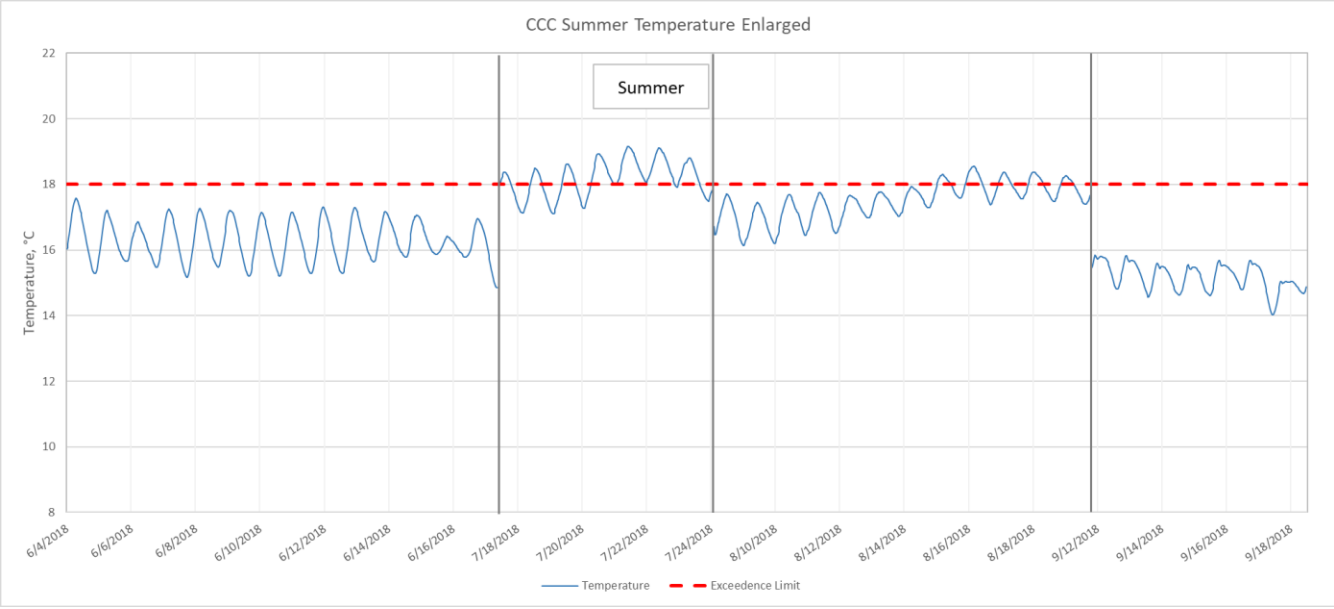
At UCR, the HOBO sensor recorded temperatures that exceeded the 18°C threshold for 18.33% of the measurements taken. Sensitive fish such as the Southern Steelhead prefer temperatures in the range of 13 to 21°C (Moyle 2002). Note that temperature data collected is not continuous throughout the year as they were deployed for two-week time periods each month. Automatic readings were taken at 30-minute increments for all deployments.



The HOBO DO sensor at CCC had temperatures that exceeded 18°C in 4.63% of readings.



The HOBO temperature data in the following graph shows an expanded view of June 4 to September 20, where temperatures frequently exceeded 18°C. This period accounts for 99.4% of temperature exceedances in WY 2018 at CCC. July was the warmest month, accounting for just over 65% of temperatures over 18°C.



Dissolved Oxygen

As with temperature data, continuous DO data provides information on how often and for how long DO concentrations fall below levels protective of sensitive wildlife. The CCRWQCB Central Coast Basin Plan

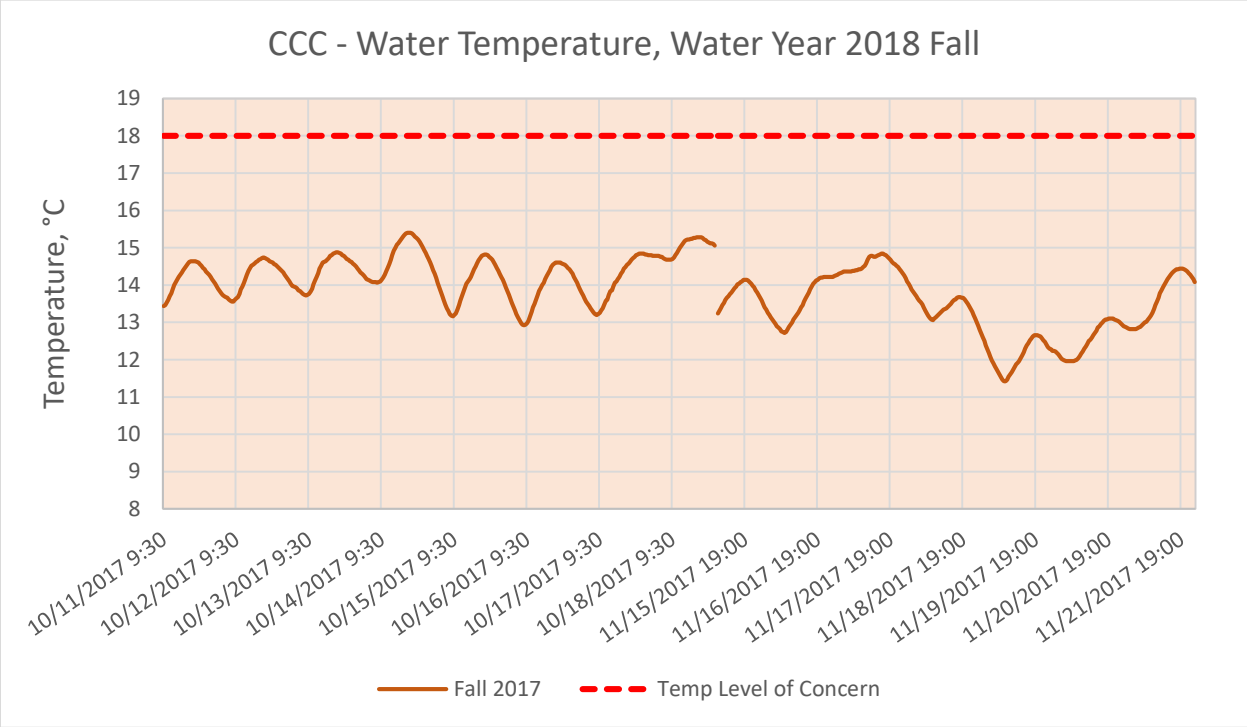
designated Chorro Creek and its watershed as the COLD and SPAWN beneficial uses, which means that DO levels must remain greater than 7 mg/L to be protective of cold-water fish and spawning habitat.

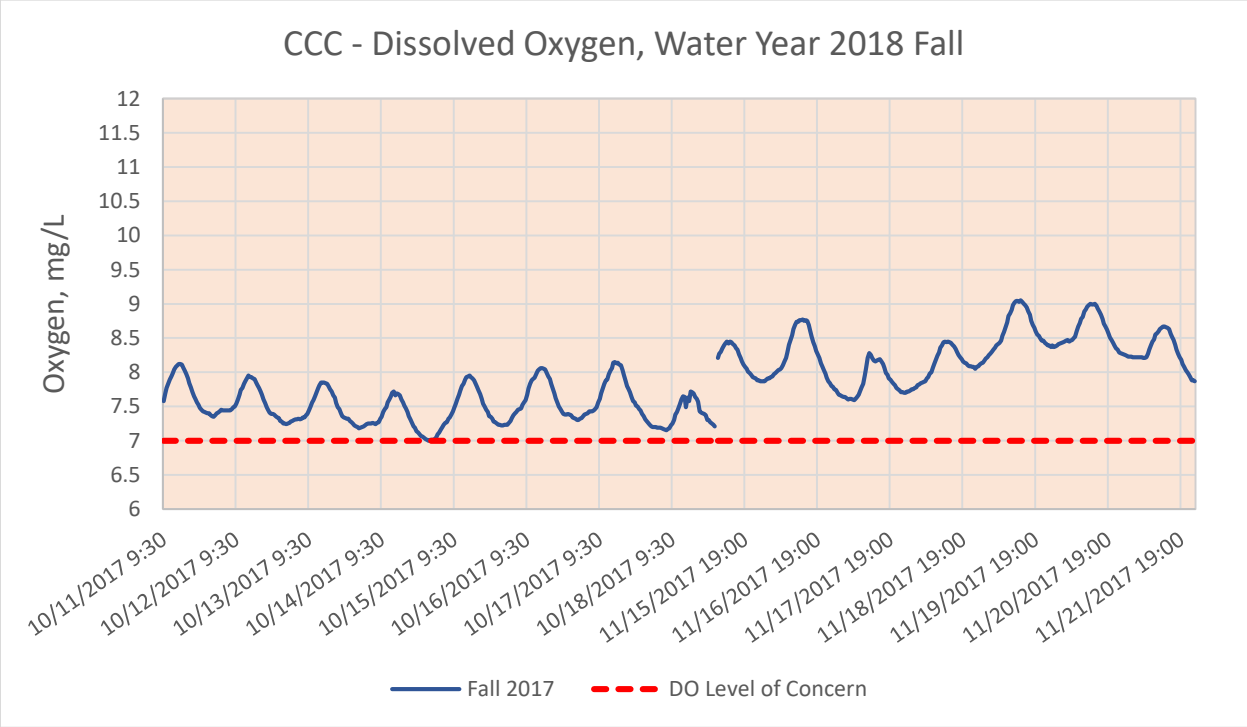
The following graphs show data with date gaps condensed on the horizontal axis. The dissolved oxygen meters are deployed approximately two weeks at a time, and the elapsed time between these deployments is not reflected in the horizontal scale. The length of deployments varied depending on field conditions, concerns about storms that could damage equipment, etc. There are some months where no data was collected due to high flows or equipment malfunction.

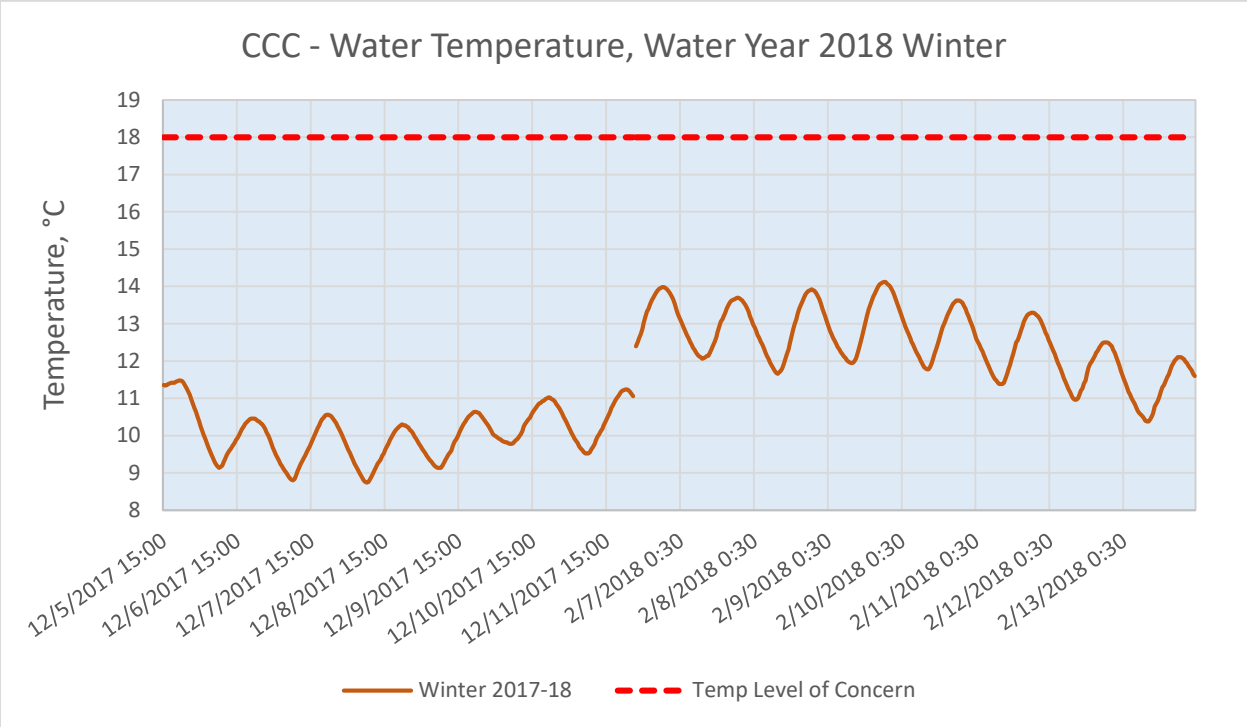
Also note that we have extended the duration of the summer data collection season to the end of September to compensate for the early fall cut-off that occurs in the water year.

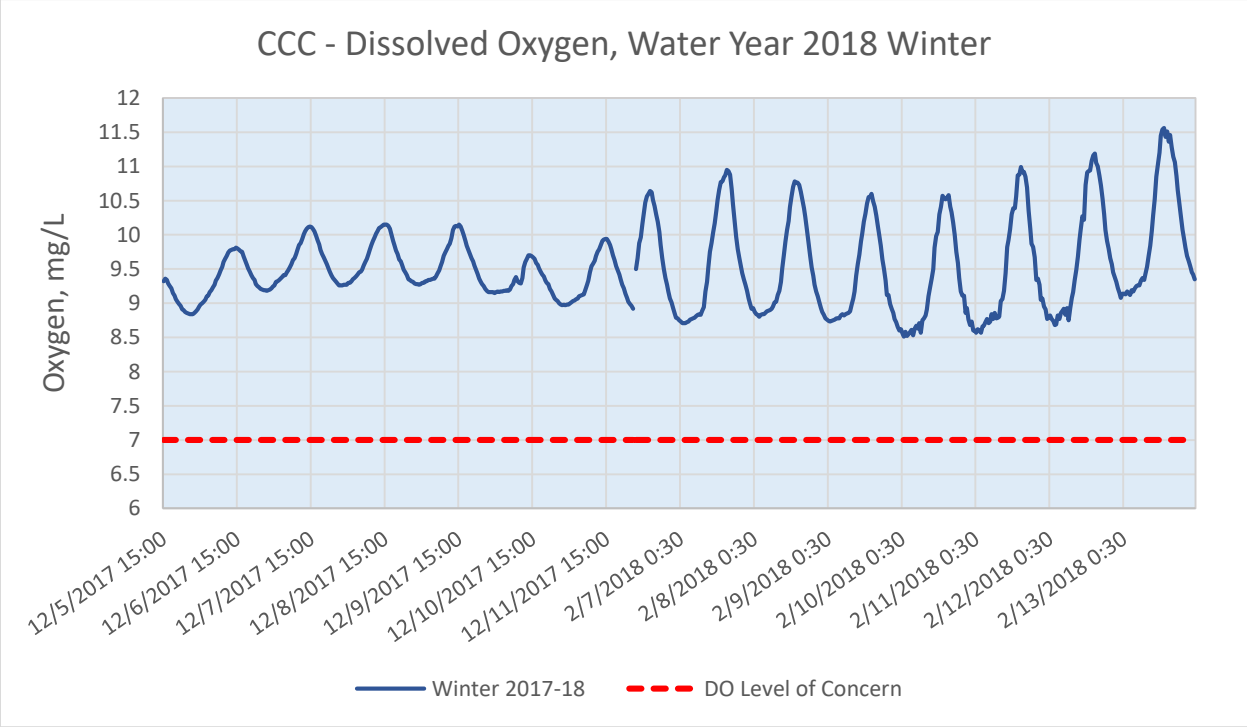
Data from the winter season at CCC was limited due to equipment issues and high flows. Due to equipment issues, reliable data was not available for UCR for WY2018, and thus it was excluded from this analysis.

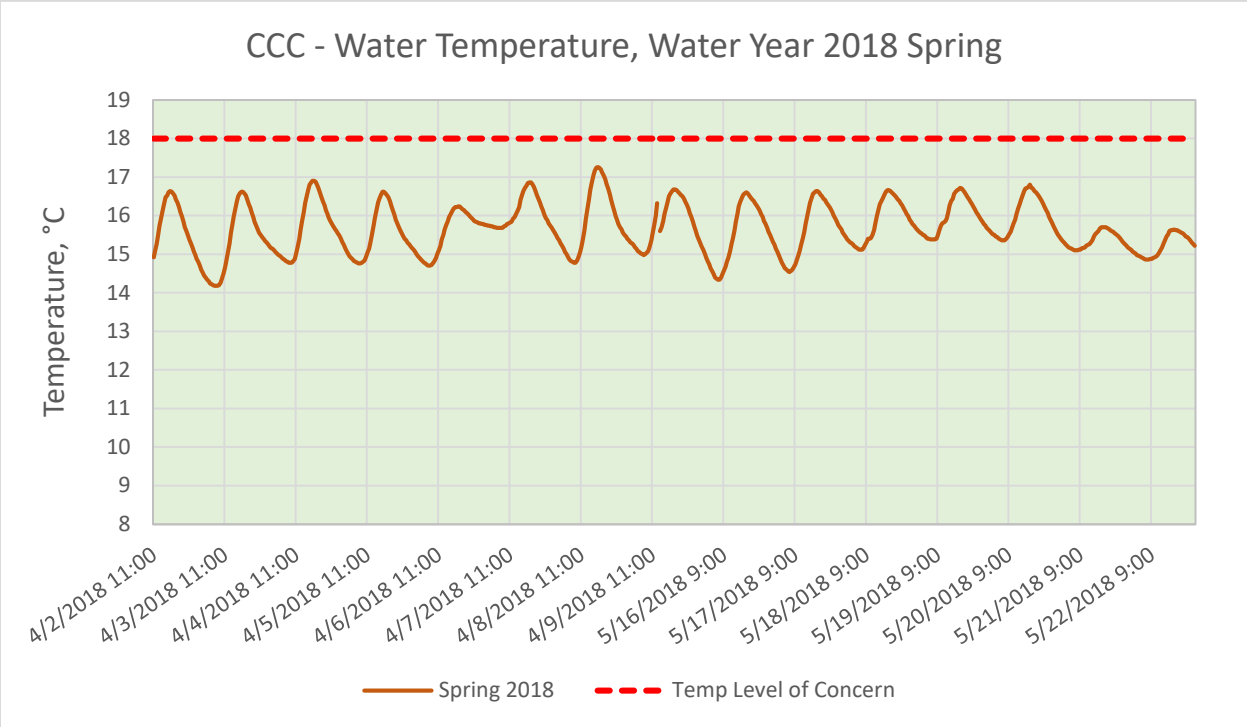
DO and temperature data for CCC is provided side-by-side, by season, to illustrate how DO and temperature data trended together.

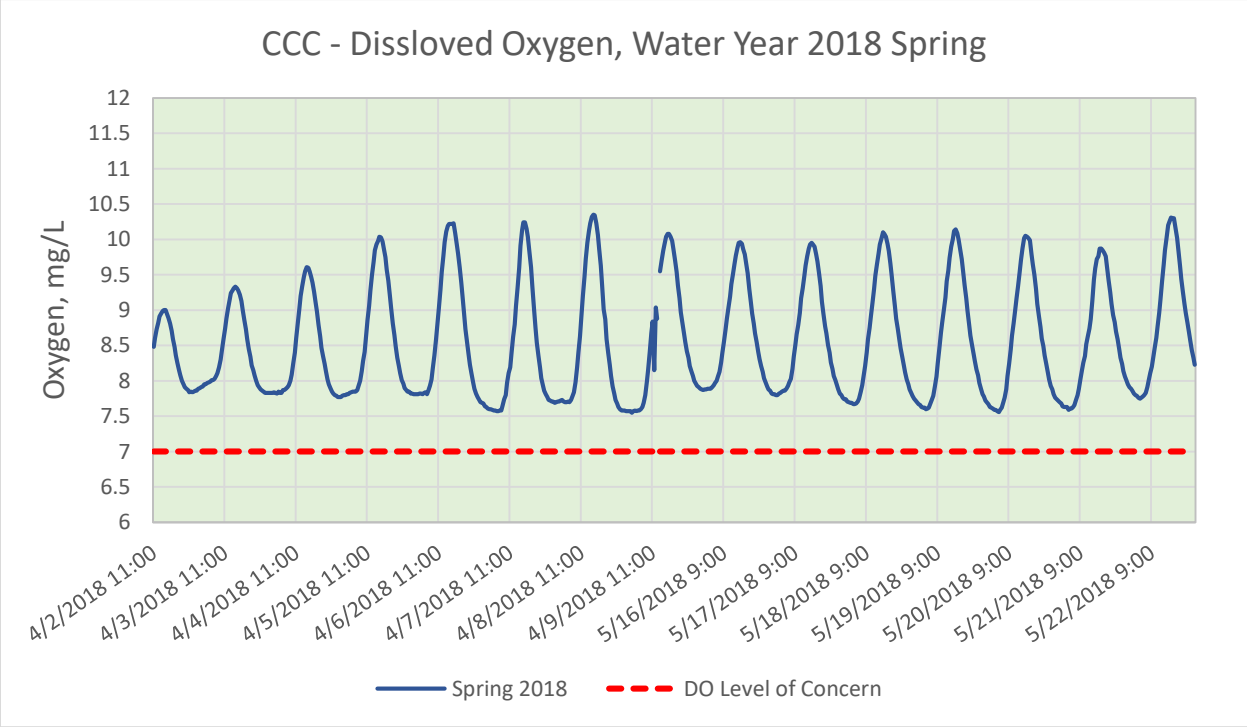

CCC - Water Temperature, Water Year 2018 Fall
Temperature, °C
19
18
17
16
15
14
13
12
11
10
9
8
10/11/2017 9:30
10/12/2017 9:30
10/13/2017 9:30
10/14/2017 9:30
10/15/2017 9:30
10/16/2017 9:30
10/17/2017 9:30
10/18/2017 9:30
11/15/2017 19:00
11/16/2017 19:00
11/17/2017 19:00
11/18/2017 19:00
11/19/2017 19:00
11/20/2017 19:00
11/21/2017 19:00
Fall 2017
Temp Level of Concern


CCC - Dissolved Oxygen, Water Year 2018 Fall
Oxygen, mg/L
12
11.5
11
10.5
10
9.5
9
8.5
8
7.5
7
6.5
6
10/11/2017 9:30
10/12/2017 9:30
10/13/2017 9:30
10/14/2017 9:30
10/15/2017 9:30
10/16/2017 9:30
10/17/2017 9:30
10/18/2017 9:30
11/15/2017 19:00
11/16/2017 19:00
11/17/2017 19:00
11/18/2017 19:00
11/19/2017 19:00
11/20/2017 19:00
11/21/2017 19:00
Fall 2017
DO Level of Concern


CCC - Water Temperature, Water Year 2018 Winter
Temperature, °C
19
18
17
16
15
14
13
12
11
10
9
8
12/5/2017 15:00
12/6/2017 15:00
12/7/2017 15:00
12/8/2017 15:00
12/9/2017 15:00
12/10/2017 15:00
12/11/2017 15:00
2/7/2018 0:30
2/8/2018 0:30
2/9/2018 0:30
2/10/2018 0:30
2/11/2018 0:30
2/12/2018 0:30
2/13/2018 0:30
Winter 2017-18
Temp Level of Concern


CCC - Dissolved Oxygen, Water Year 2018 Winter
Oxygen, mg/L
12
11.5
11
10.5
10
9.5
9
8.5
8
7.5
7
6.5
6
12/5/2017 15:00
12/6/2017 15:00
12/7/2017 15:00
12/8/2017 15:00
12/9/2017 15:00
12/10/2017 15:00
12/11/2017 15:00
2/7/2018 0:30
2/8/2018 0:30
2/9/2018 0:30
2/10/2018 0:30
2/11/2018 0:30
2/12/2018 0:30
2/13/2018 0:30
Winter 2017-18
DO Level of Concern


CCC - Water Temperature, Water Year 2018 Spring
Temperature, °C
19
18
17
16
15
14
13
12
11
10
9
8
4/2/2018 11:00
4/3/2018 11:00
4/4/2018 11:00
4/5/2018 11:00
4/6/2018 11:00
4/7/2018 11:00
4/8/2018 11:00
4/9/2018 11:00
5/16/2018 9:00
5/17/2018 9:00
5/18/2018 9:00
5/19/2018 9:00
5/20/2018 9:00
5/21/2018 9:00
5/22/2018 9:00
Spring 2018
Temp Level of Concern


CCC - Dissloved Oxygen, Water Year 2018 Spring
Oxygen, mg/L
12
11.5
11
10.5
10
9.5
9
8.5
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7.5
7
6.5
6
4/2/2018 11:00
4/3/2018 11:00
4/4/2018 11:00
4/5/2018 11:00
4/6/2018 11:00
4/7/2018 11:00
4/8/2018 11:00
4/9/2018 11:00
5/16/2018 9:00
5/17/2018 9:00
5/18/2018 9:00
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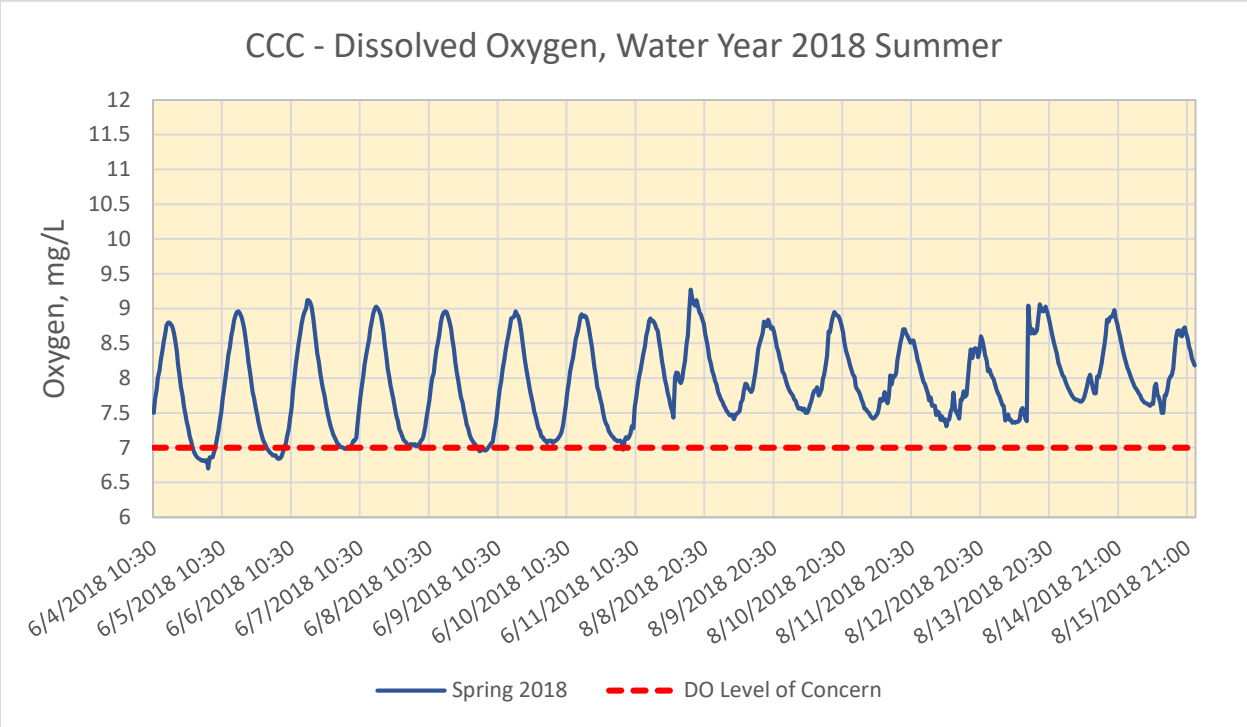
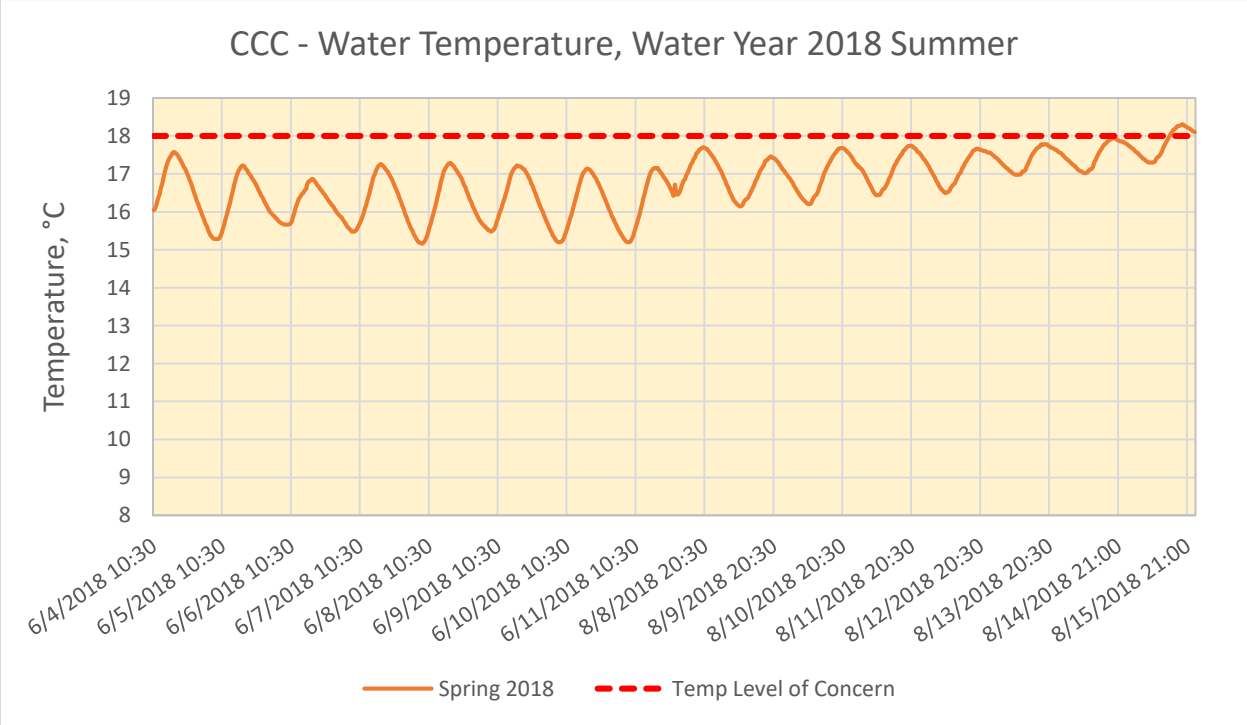
5/20/2018 9:00
5/21/2018 9:00
5/22/2018 9:00
Spring 2018
DO Level of Concern



Note that equipment was not deployed in July 2018.



Discussion:

At CCC, only in early June 2018 were DO levels below 7mg/L observed. This corresponds with some of the highest water temperatures observed in WY 2018 at the site. When accounting for the DO lower limit exceedance rate, the 39 measurements below 7mg/L constitute 1.41%, or 19.5 hours out of 1386.5 observed hours. See the tables below.

Dissolved Oxygen Exceedance		
Site	**Season**	**Exceedance Rate**
CCC	Winter	0%
CCC	Spring	0%
CCC	Summer	2.48%
CCC	Fall	0%

Dissolved Oxygen Exceedance, Annual Rate	
Site	**Exceedance Rate**
CCC	1.41%

As expected, months with cooler average water temperatures tended to have higher average dissolved oxygen values. The peaks and dips in the graphs corresponded with diurnal fluctuations in temperature and sunlight. Some sections of the graphs appear to have noise over short periods of time, as in the February and August deployments at CCC. Biofouling, especially the growth of microalgae near the sensors, can influence the dissolved oxygen levels locally and cause erratic fluctuations in the measurements. Those noisy data that were included in this report were determined by staff to fall within the expected range. Data was discarded if 1) An overall decreasing trend occurred in the second week of a two-week deployment, which was thought to relate to increased biofouling interfering with the sensor, or 2) Measurements taken at the start and end of a deployment were missing or erroneous. The HOBO relies on a reading taken with a separate meter to "correct" drift in the meter readings. If these two data sets were greatly dissimilar, then the data was discarded.

As discussed previously, dissolved oxygen data from UCR was not included in this report due to equipment issues. The lack of usable DO data for WY 2018 was disappointing. Steps are underway to replace the HOBO sensors with more accurate and reliable equipment. The goal is to have this new equipment in place prior to when water levels begin to drop (typically in late spring or early summer) and temperatures and DO begin to approach levels critical for steelhead.

Quarterly Nutrient Monitoring

The Estuary Program wanted to be able to assess nutrient levels at sites throughout the watershed. The information provides long-term trend data and assists in targeting efforts such as restoration or conservation.

Estuary Program staff visit nine sites four times a year to collect samples for analysis by a laboratory for nitrate as nitrogen (NO_3-N, mg/L) and for orthophosphate as phosphorus (PO_4-P, mg/L).

Analytical Specifications: The Estuary Program collects samples using standard techniques. The samples are stored in the dark on ice and then delivered by a courier to a certified laboratory for analysis within the specified hold time. The analysis specifications are as follows:

Nitrate as Nitrogen (mg/L)

Specification	Value
Method Number	EPA 300.0
Minimum Detection Limit	0.022 mg/L
Project Quantitation Limit	0.10 mg/L
Hold Time	48 hours
Sample storage conditions	4°C in the dark

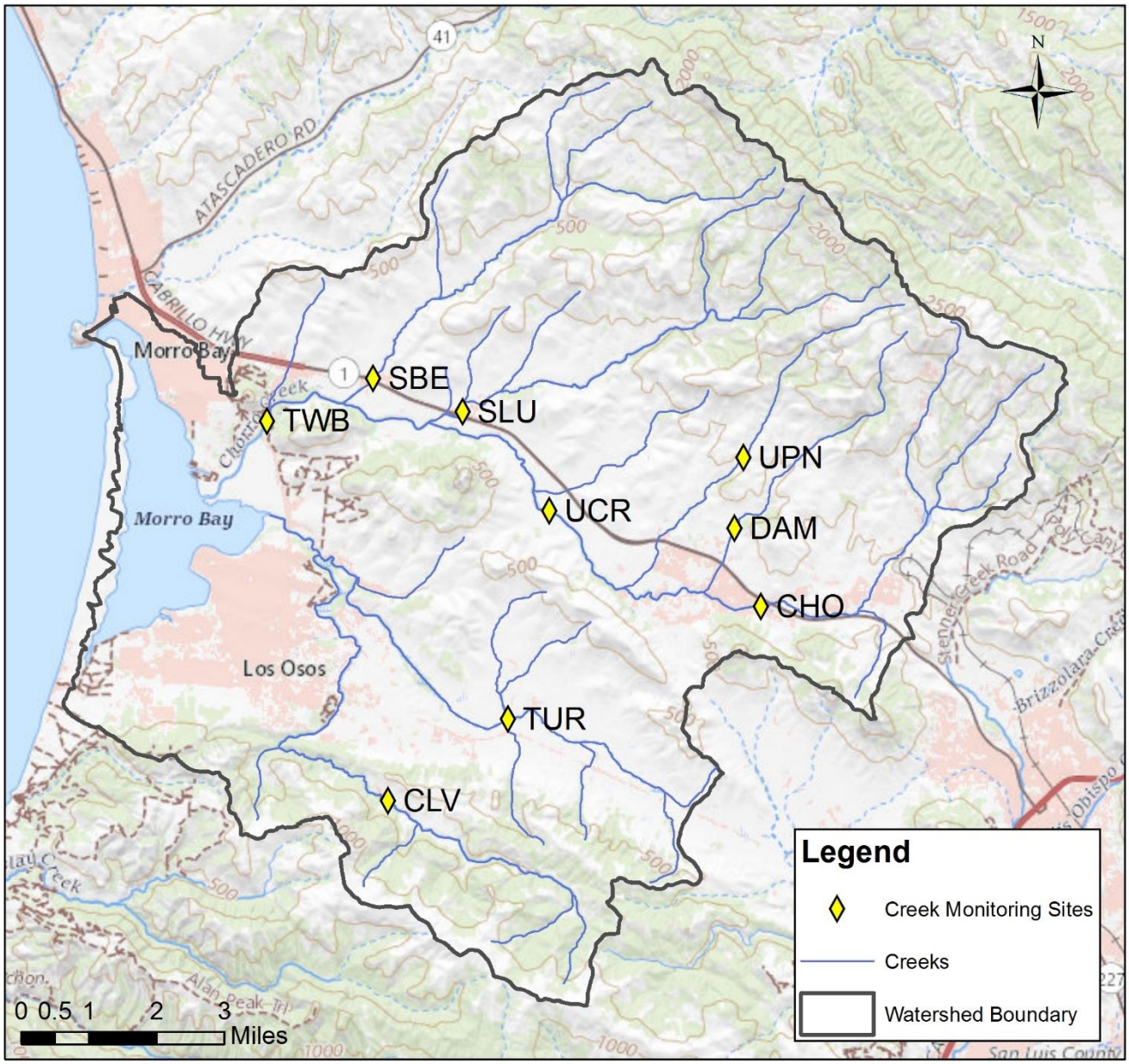
Orthophosphate as Phosphorus (mg/L)

Specification	Value
Method Number	EPA 365.1
Minimum Detection Limit	0.017 mg/L
Project Quantitation Limit	0.050 mg/L
Hold Time	48 hours
Sample storage conditions	4°C in the dark

Note that the laboratory occasionally dilutes the sample prior to analysis if the nutrient concentrations are elevated. This dilution impacts the minimum detection limit and project quantitation limit for the analytical results.

Monitoring Locations: The sites were selected to represent Chorro and Los Osos Creeks, as well as their tributaries. The sites include Dairy Creek middle (site code DAM), Pennington Creek upper (UPN), Chorro Creek upper (CHO), Chorro Creek middle (UCR), Chorro Creek lower (TWB), San Luisito Creek lower (SLU), San Bernardo Creek lower (SBE), Warden Creek middle (TUR), and Los Osos Creek upper (CLV). See map for site locations.

Morro Bay Watershed Quarterly Nutrient Monitoring Sites



Nitrates

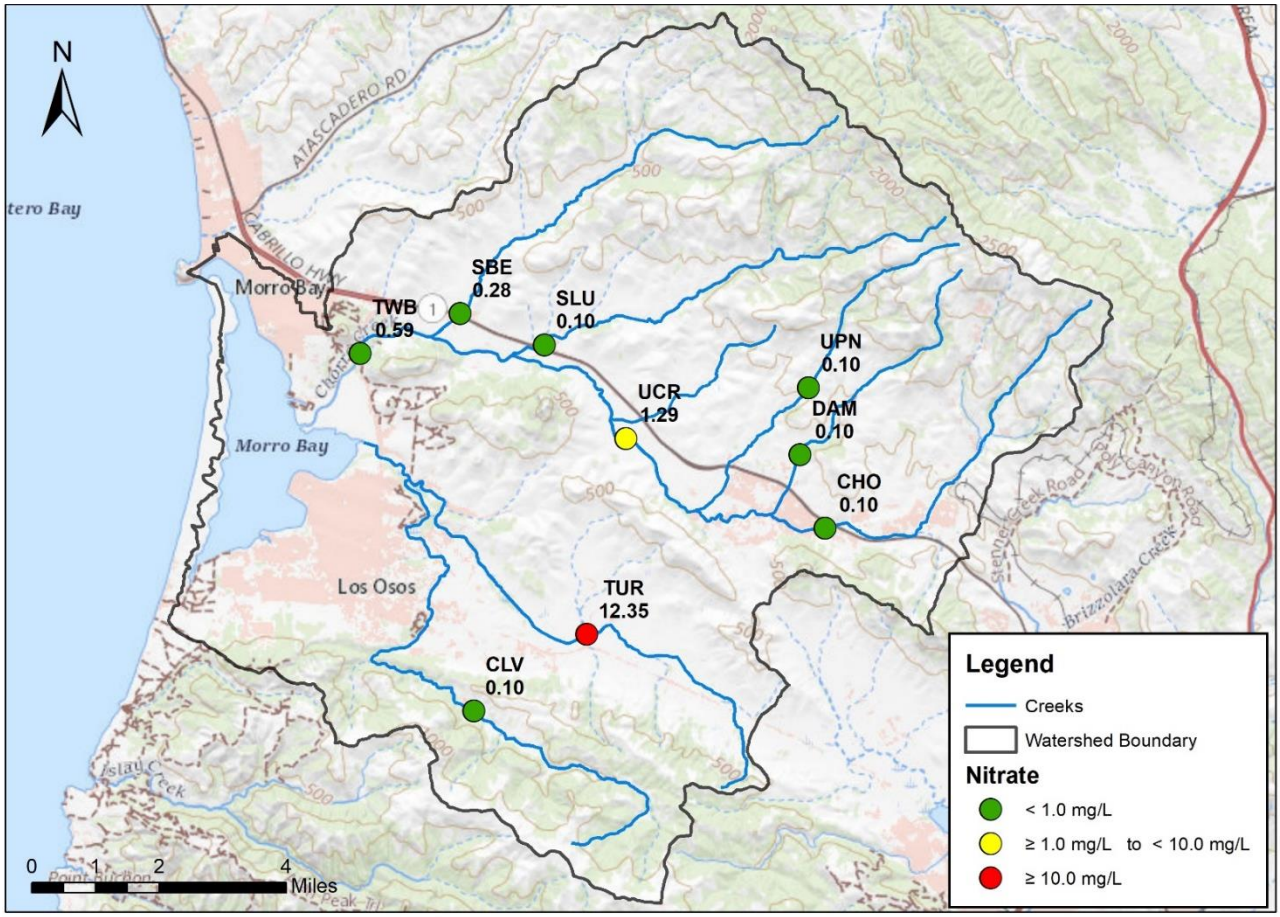
Nitrate results are compared to two standards. In freshwater systems, the CCRWQCB considers a water body to be impaired by nitrates if nitrate as nitrogen (NO_3-N) concentrations are greater or equal to 1 mg/L and if the site shows other signs of impact such as widespread algal growth and low DO concentrations. There is also a drinking water standard for nitrate to be protective of human health, which is less than or equal to 10 mg/L. The Estuary Program assessment utilized the following scores:

- Good (green) for nitrate as nitrogen concentrations < 1 mg/L (protective of aquatic and human health)

- Fair (yellow) for nitrate as nitrogen concentrations ≥ 1 mg/L and < 10 mg/L
- Poor (red) for nitrate as nitrogen concentrations ≥ 10 mg/L (exceeds level protective of human health)

The map below indicates the monitoring locations and the average nitrate as nitrogen concentration at each site for WY 2018. For sites with year-round flow, this represents four readings. The number of samples varies by sites, as some sites go dry during the summer.

Average Nitrate as Nitrogen (mg/L) Concentrations for WY 2018



Changes from the historical average as compared to results from WY 2018 are below:

Nitrates as Nitrogen (mg/L)

Site Code	CHO	CLV	DAM	SBE	SLU	TUR	TWB	UCR	UPN
Historical Average, mg/L	0.15	0.10	0.15	0.74	0.26	7.15	0.90	3.85	0.12
WY 2018 Average, mg/L	0.10	0.10	0.10	0.28	0.10	12.35	0.59	1.30	0.10
WY 2018 Average Compared to Historical Average, mg/L	-0.05	0.00	-0.05	-0.46	-0.16	5.20	-0.32	-2.56	-0.02

Values highlighted in green show an improvement over the historical average and values in yellow show a worsening measurement over the historical average. Values without color did not show substantial change. Historical data includes quarterly monitoring from WY 2016 through WY 2018.

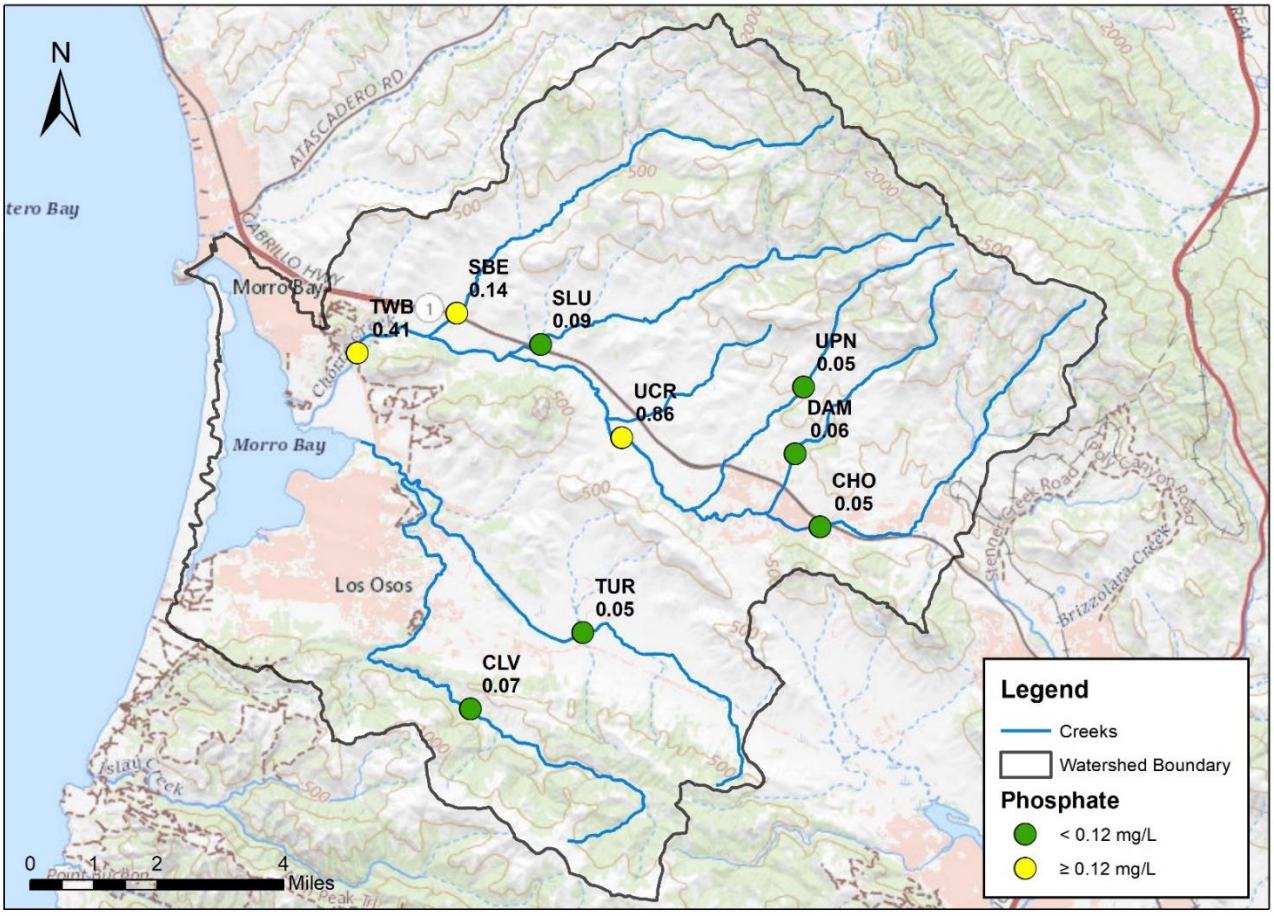
Orthophosphates as Phosphorus

Data is compared to the targets in the Pajaro River nutrient objectives guidance document, as referenced on the CCAMP website. An orthophosphate as phosphorus value of 0.12 mg/L is used for comparison to Morro Bay watershed data. There is no standard protective of human health for orthophosphates. The Estuary Program assessment utilized the following scores:

- Good (green) for orthophosphate as phosphorus concentrations < 0.12 mg/L
- Fair (yellow) for orthophosphate as phosphorus concentrations ≥ 0.12 mg/L

The map below indicates the monitoring locations and the average orthophosphate as phosphorus concentrations at each site for WY 2018. For sites with year-round flow, this represents four readings. The number of samples varies by sites, as some sites go dry during the summer.

Average Orthophosphate as Phosphorus (mg/L) Concentrations for WY 2018



Changes from the historical average as compared to results from WY 2018 are below:

Orthophosphate as Phosphorus (mg/L)

Site Code	CHO	CLV	DAM	SBE	SLU	TUR	TWB	UCR	UPN
Historical Average, mg/L	0.03	0.03	0.08	0.13	0.10	0.05	0.43	1.00	0.05
WY 2018 Average, mg/L	0.05	0.07	0.06	0.15	0.09	0.05	0.41	0.86	0.05
WY 2018 Average Compared to Historical Average, mg/L	0.03	0.04	-0.01	0.01	0.00	0.00	-0.02	-0.14	0.00

Values highlighted in green show an improvement over the historical average and values in yellow show a worsening measurement as compared to the historical average. Values without color did not show substantial change. Historical data includes quarterly monitoring from WY 2016 through WY 2018.

Discussion:

The highest nitrate values in the watershed were measured on Warden Creek (TUR). Chorro Creek immediately downstream of the CMC WWTP outfall (UCR) also had elevated nitrate concentrations relative to upstream and downstream levels. Orthophosphate concentrations are higher in Chorro Creek than in Los Osos Creek, with UCR, SBE, and TWB above the screening level target.

Impairment in nutrients often tracks with large DO fluctuations and excess algae. As DO data is not available for UCR, temperature can be used as a proxy to estimate when DO levels were likely low. UCR experienced elevated temperature in 20.53% of overall measurements, with most of those exceedances concentrated during the summer season. Thus, it is likely that less-than-ideal DO conditions occurred during the summer of WY18 and nutrient enrichment could have played a role.

At TUR, which had elevated nitrate concentrations, six monthly grab sample DO readings were collected in WY 2018 from June through December. The readings varied from 5.40 to 8.14 mg/L, with a median value of 5.56 mg/L. The site was not monitored during the summer due to lack of flows. Thus, it is unknown whether the low DO readings were related to low flows or to nutrient loading impacts. The 2018 water year is categorized as "dry" overall.

The presence of algae is an indicator of nutrient impairment. Data collected to date was too limited to report. We collect observational data when we conduct quarterly nutrient monitoring data, so we will share this algae presence/absence information in the future

Data Availability

The data is available from the California Environmental Data Exchange Network (CEDEN), a State Water Resources Control Board managed data portal. To retrieve Quarterly Nutrient data,

- Visit www.CEDEN.org
- Click on Find Data
- For Program, choose Morro Bay National Estuary Program
- For Quarterly Nutrient Monitoring: For Stations, choose Dairy Creek within cattle enclosure (site code DAM), Pennington Creek upstream from horse corral (UPN), Chorro Creek at Camp SLO (CHO), Chorro Creek at upper Chorro Creek Ecological Reserve (UCR), Chorro Creek at South Bay Boulevard (TWB), San Luisito Creek @ Adobe Rd (SLU), San Bernardo Creek at Adobe Rd (SBE), Warden Creek at Turri Road (TUR), and Los Osos Creek Clark Valley Road (CLV)
- Click on Retrieve Data

For continuous monitoring DO and temperature data, contact the Estuary Program.

For additional details, contact the Estuary Program at 805-772-3834 or staff@mbnep.org