



Morro Bay Watershed Creek Health For Water Year 2019

Date Range: October 1, 2018 to September 30, 2019

Analytes: 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 State Water Resources Control Board. This QAPP document contains the monitoring locations, protocols, equipment specifications, and other details that allow users to assess the quality of the collected data. The full QAPP document is available upon request.

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 2019 (WY2019).

Equipment Specification: The Estuary Program deploys [HOBO TidbiT MX 2203 Temperature 400’ Data Loggers](#) at monitoring sites throughout the watershed. These units monitor the daily fluctuations and seasonal trends of water temperature in Morro Bay watershed creeks. The loggers were deployed in streams from spring through summer with readings collected every 30 minutes. Some units remained deployed year round, while some were retrieved prior to large winter storm events and then redeployed in the spring when flows subsided.

Specifications for the TidbiT temperature loggers are as follows:

Specification	Value
Measurement/Operating Range	-20° to 70°C in air -20° to 50°C in water
Accuracy	±0.25°C from -20° to 0°C ±0.2°C from 0° to 70°C
Resolution	0.01°C

While the TidbiT temperature loggers do not require calibration, for comparison an independent measurement was collected from a second meter at time of deployment. Periodically throughout the deployment, temperature was measured with a second meter to compare with the TidbiT temperature for quality assurance.

Due to equipment malfunctions, the Estuary Program was not able to deploy continuous dissolved oxygen loggers during WY2019. Research is underway to replace the equipment.

Monitoring Locations:

In WY2019, the Estuary Program collected continuous temperature data at five sites throughout the Morro Bay watershed, all within the Chorro Creek subwatershed (see Figure 1). Three of the five monitoring sites were chosen along Chorro Creek since it is known to support steelhead trout, a sensitive species of concern, and because historic data has shown elevated temperatures along the creek. A site on Pennington Creek and a site on San Luisito Creek were chosen because they have historically provided spawning ground for steelhead.

Current Continuous Temperature Monitoring Stations

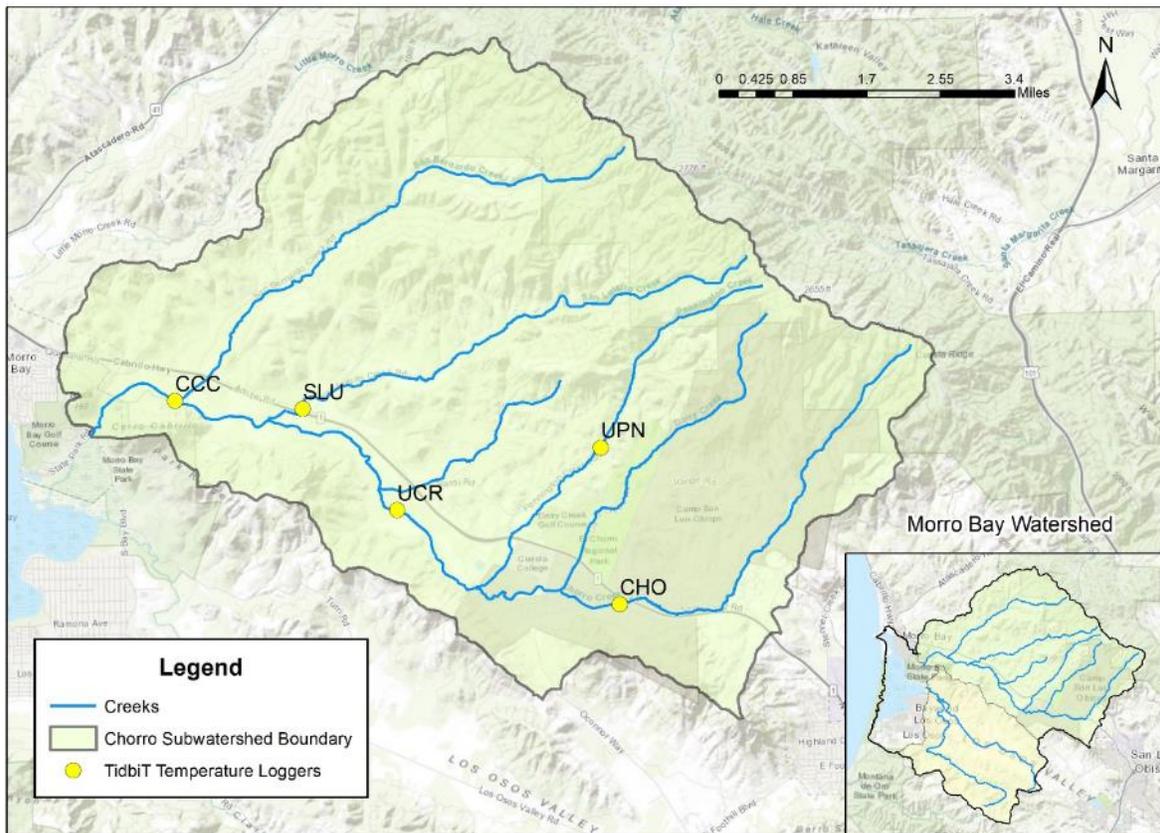


Figure 1: Current continuous temperature monitoring sites in the Chorro Creek subwatershed.

Results:

Continuous temperature data is of value because it shows the time of day and duration of elevated temperatures. Temperature values from continuous loggers were compared to an 18°C threshold, a level selected to be protective of sensitive aquatic species, including Central California Coast Steelhead. The optimal temperature range for steelhead is between 13 and 21°C (Moyle 2002).

The following datasets show water temperature data collected at 30-minute intervals throughout WY2019 compared to the 18°C threshold. Note that data could not always be collected throughout the entire water year, and the actual deployment dates of the loggers vary by site. See Appendix A for details on deployment dates.

Chorro Creek

Water temperature data was collected at three sites along Chorro Creek:

- The uppermost monitoring site is located at Camp San Luis Obispo (site code CHO).
- The middle Chorro Creek site is downstream of the California Men's Colony Wastewater Treatment Plant (CMC WWTP) and just upstream of the Chorro Creek Ecological Reserve. The site is referred to as Upper Chorro Reserve (UCR).
- The furthest downstream monitoring site is at Chorro Creek Road (CCC) near the bottom of Chorro Creek, just upstream of Chorro Flats. It is above the zone of tidal influence from the bay.

The presence of steelhead has been confirmed at UCR and CCC in recent years.

The following graphs show water temperatures at CHO, UCR, and CCC. The first graph in each set represents the entire deployment period of the temperature logger, which varies by site. The following graphs are broken out by season for each site. The blue line indicates water temperature in °C recorded at a 30-minute intervals, and the red line indicates the 18°C threshold protective of steelhead and other sensitive species.

Camp San Luis Obispo (CHO)

The temperature logger at CHO was deployed from the start of WY2019 (October 1, 2018) until February 12, 2019, then redeployed from May 24, 2019 until the end of WY2019 (September 30, 2019).

Water Temperature - CHO

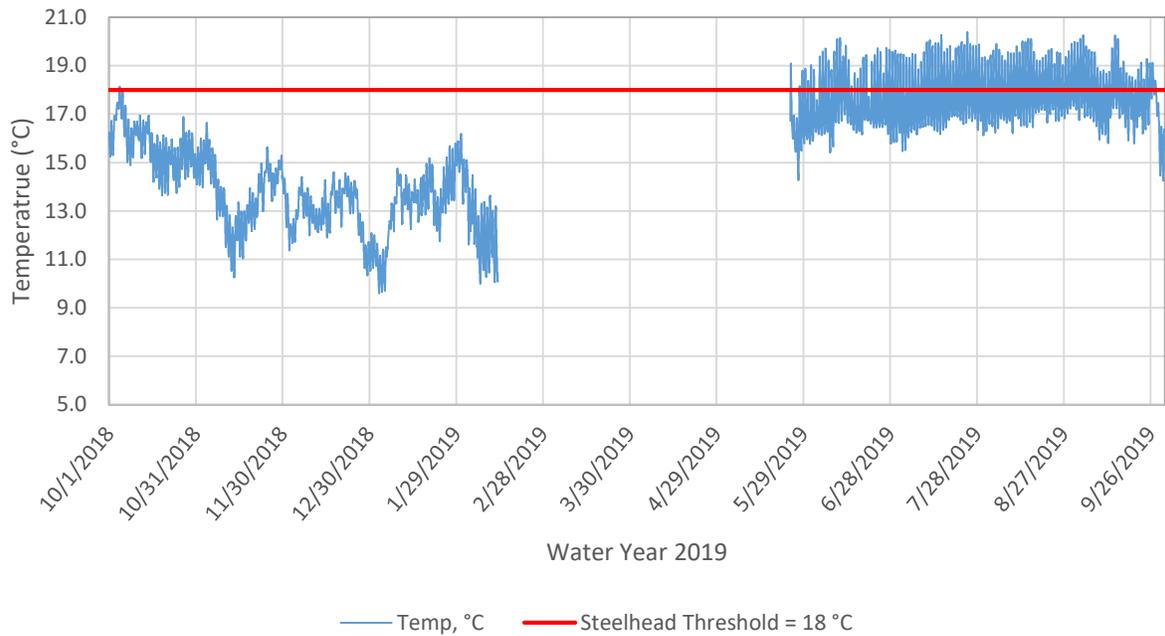


Figure 2

Fall Water Temperature - CHO

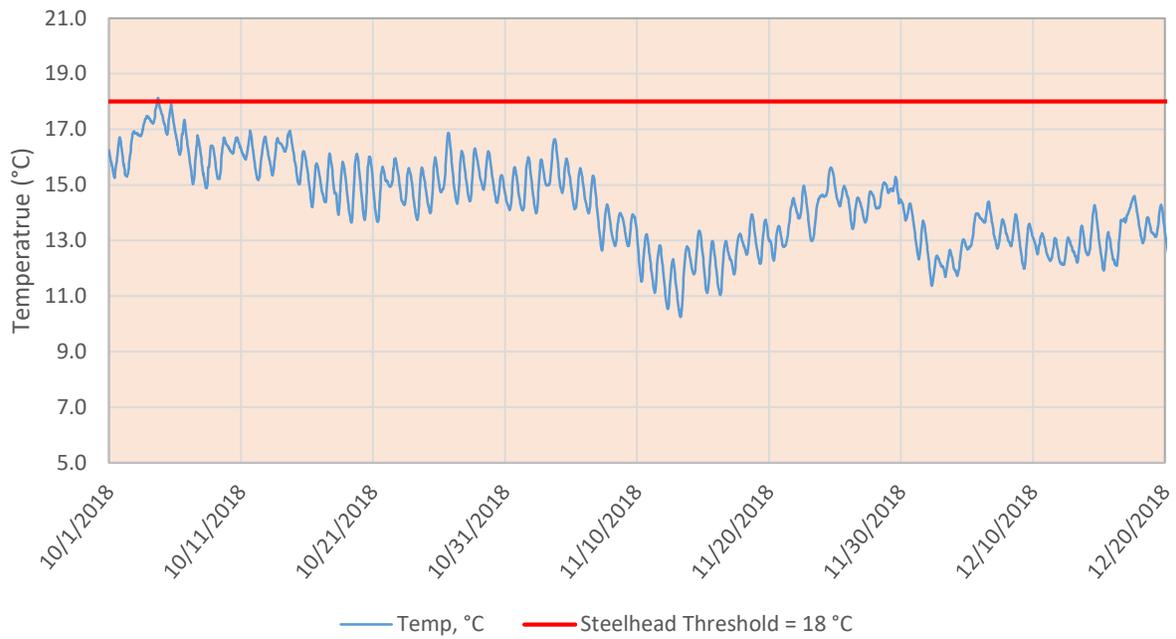


Figure 3

Winter Water Temperature - CHO

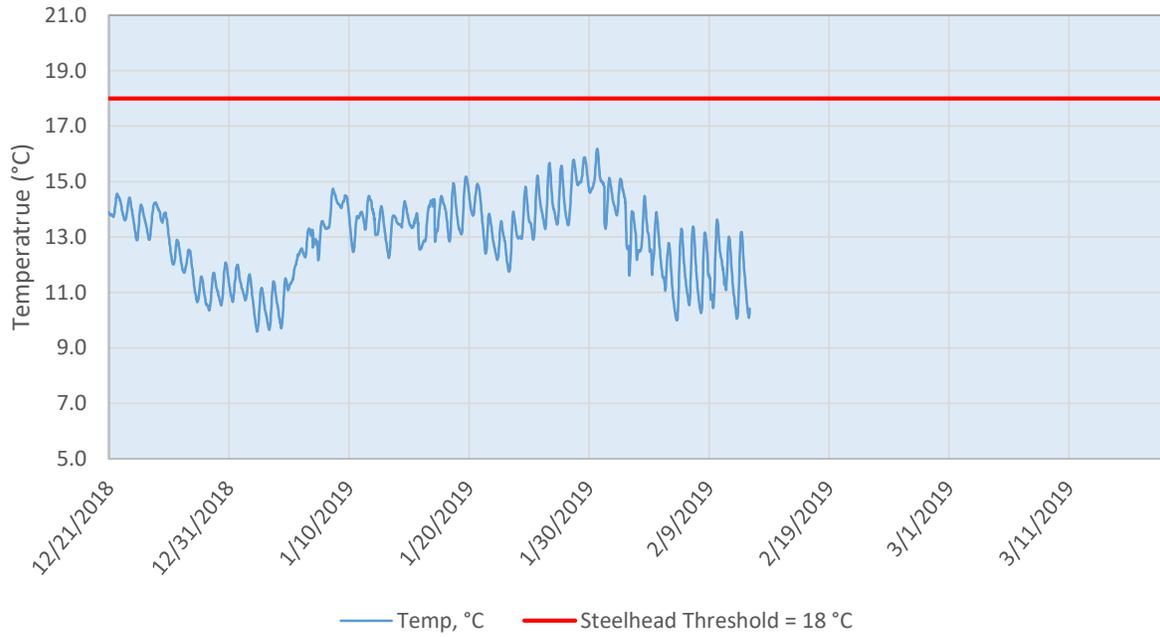


Figure 4

Spring Water Temperature - CHO

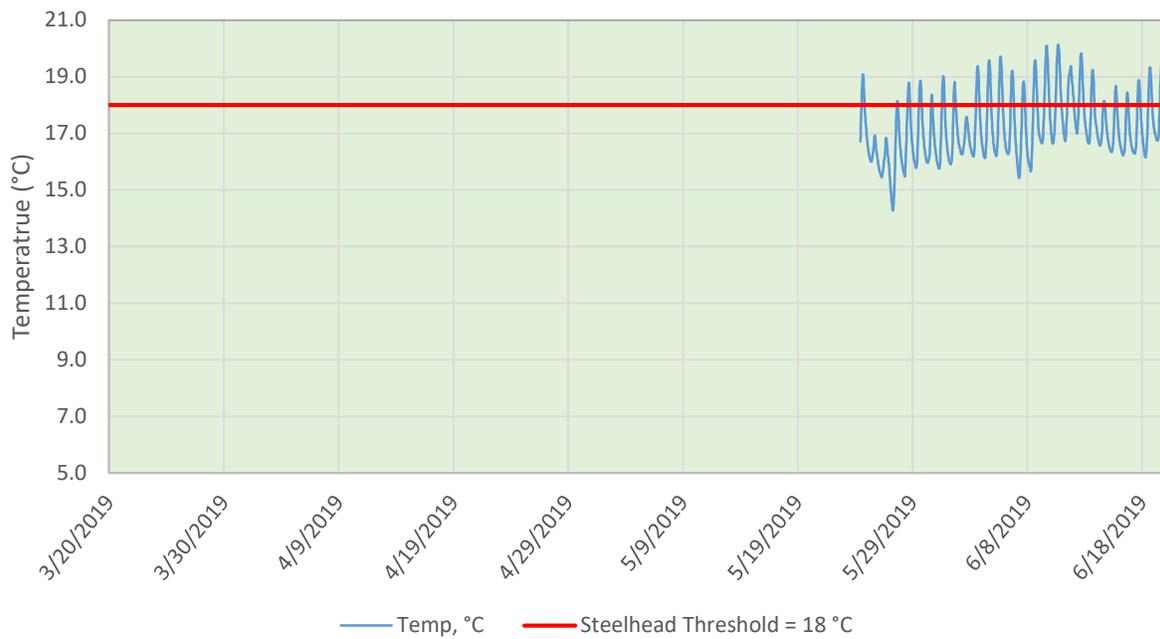


Figure 5

Summer Water Temperature - CHO

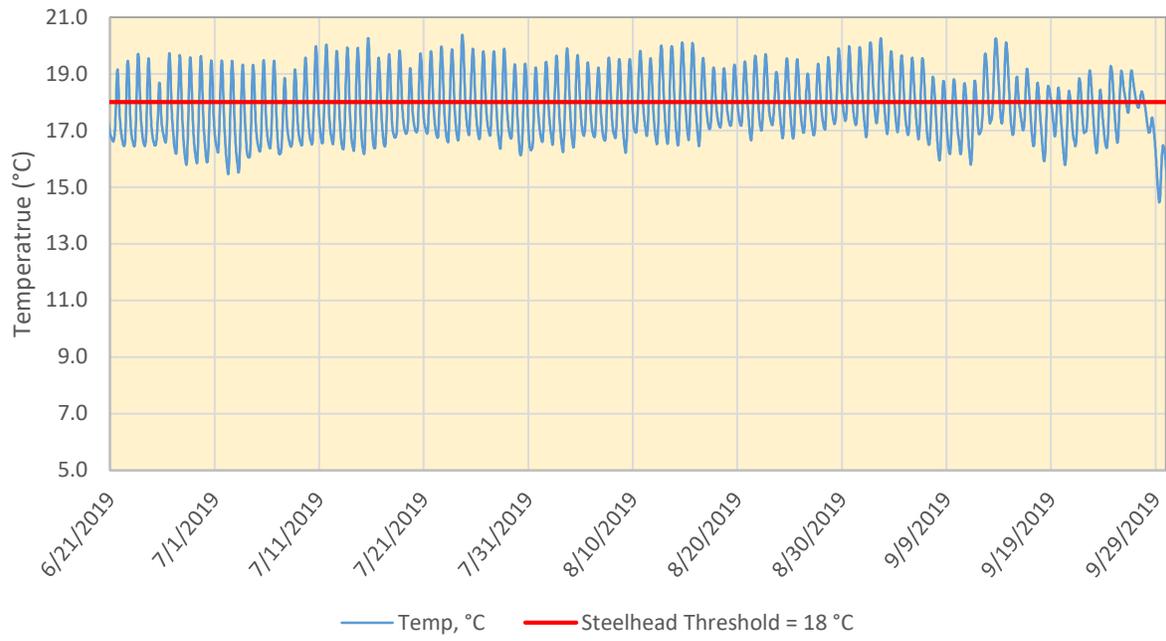


Figure 6

Upper Chorro Reserve (UCR)

The temperature logger at UCR was deployed in the summer of 2019 only. Fall, winter, and spring seasonal data are not available.

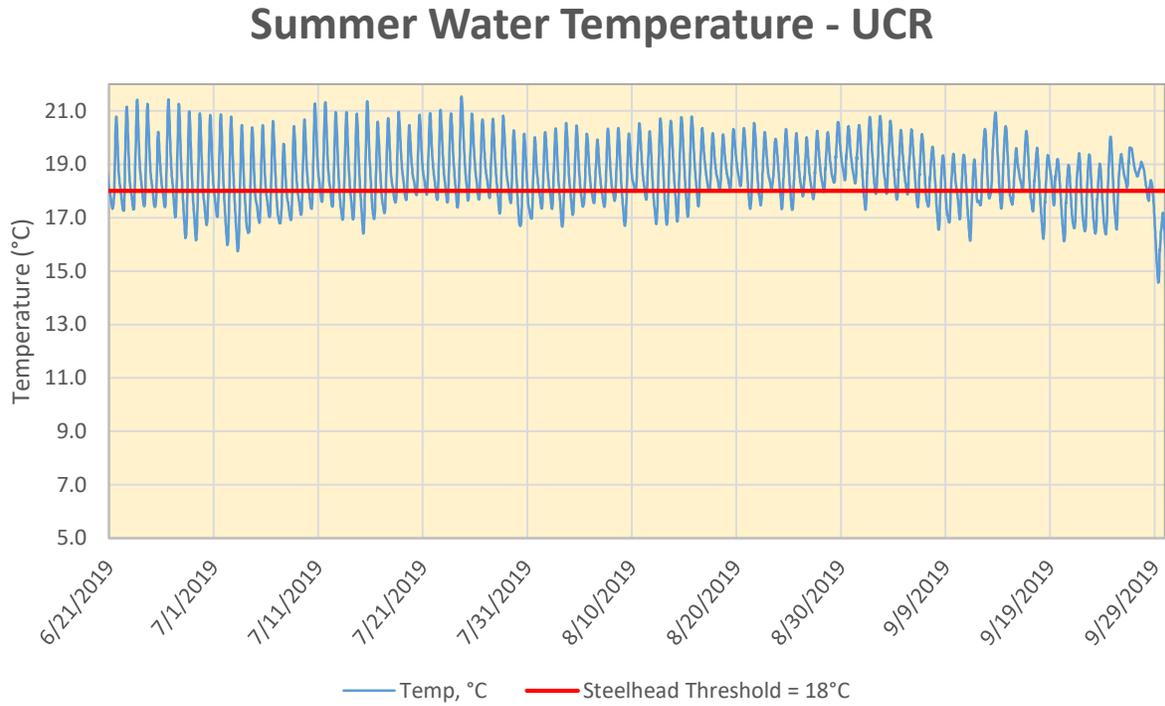


Figure 7

Chorro Creek Road (CCC)

The temperature logger at CCC was deployed from May 15, 2019 until the end of WY2019. Fall and winter seasonal data are not available.

Water Temperature - CCC

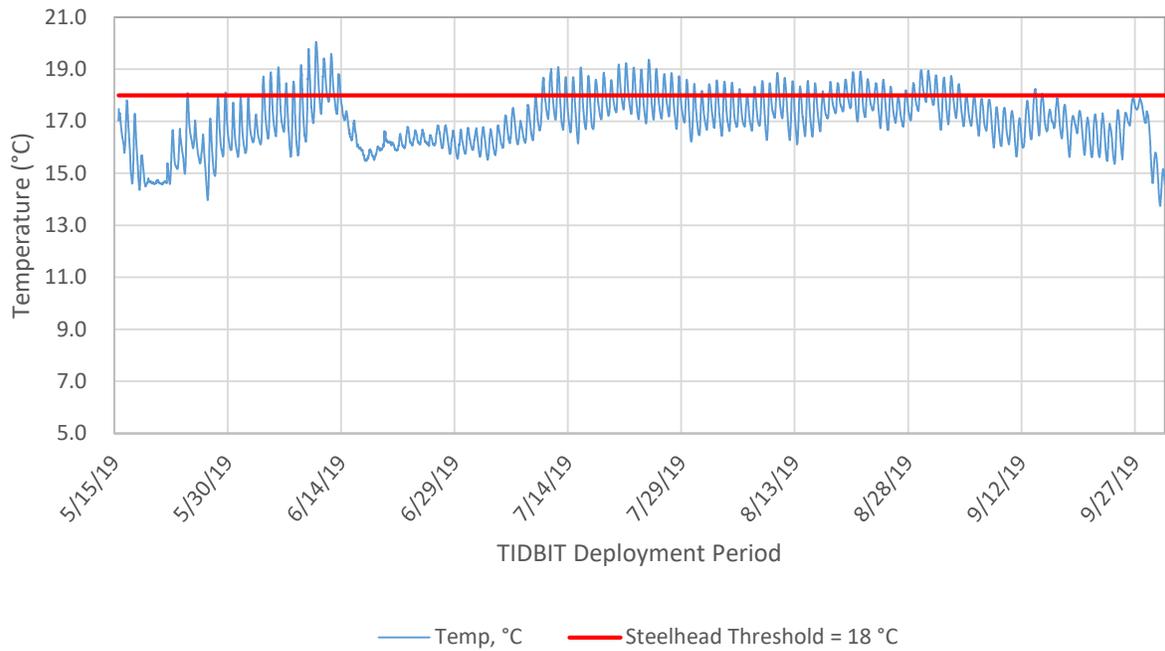


Figure 8

Spring Water Temperature - CCC

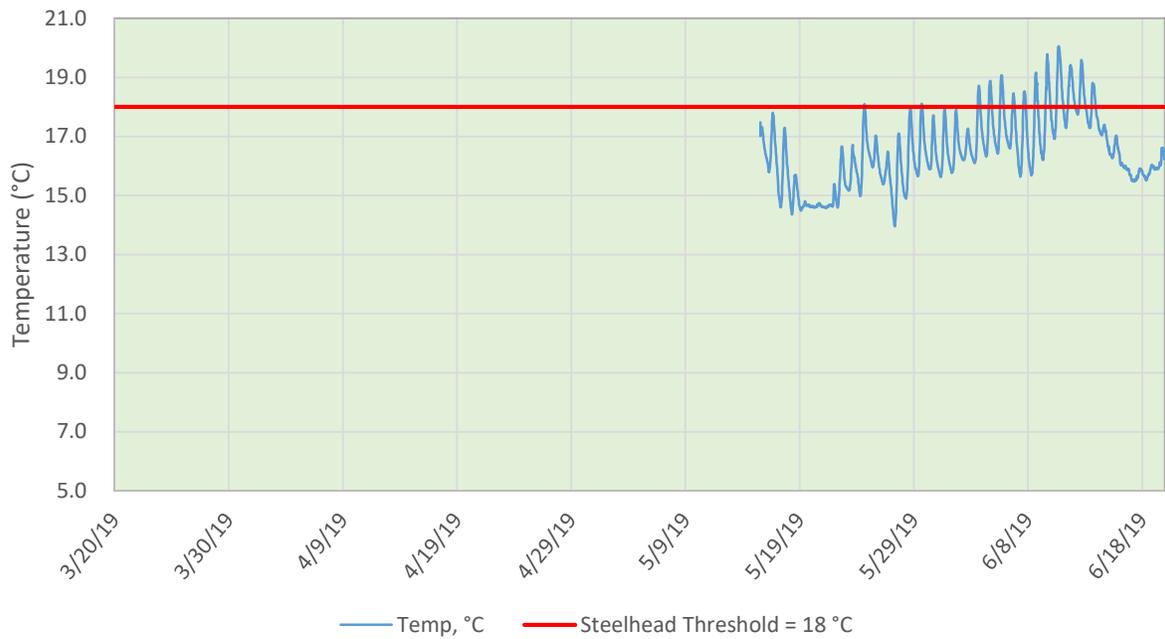


Figure 9

Summer Water Temperature - CCC

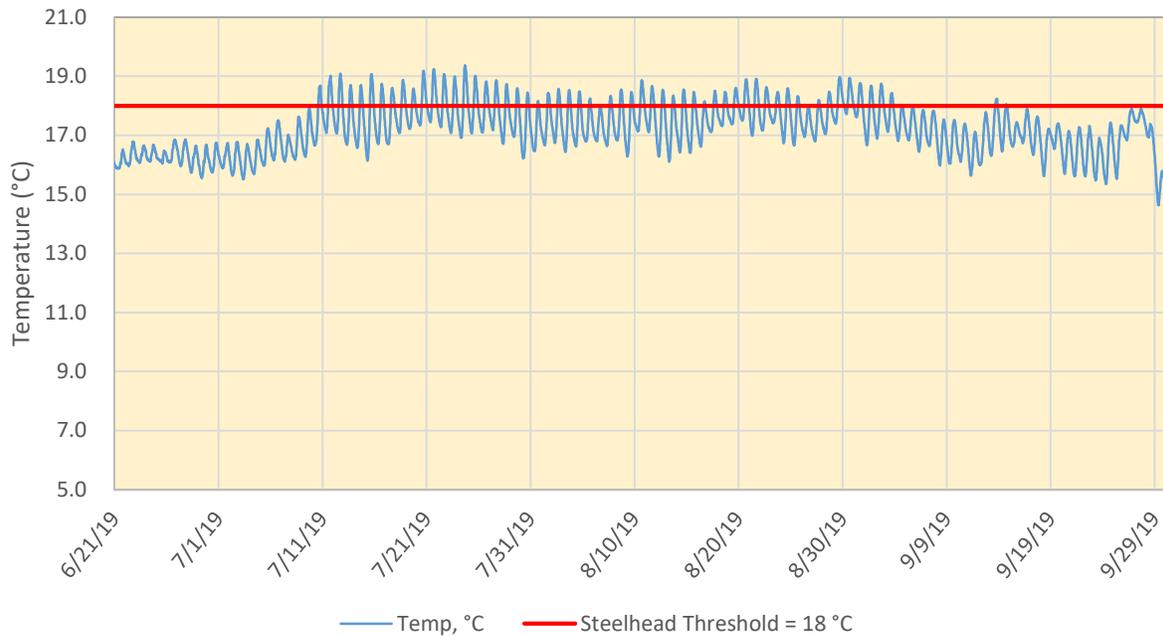


Figure 10

San Luisito Creek

San Luisito Creek is a tributary to Chorro Creek, and its confluence point is located downstream of UCR and upstream of CCC. The site is located below Adobe Road (site code SLU), and the temperature logger was located about 0.5 miles upstream of the confluence with Chorro Creek.

The first graph in the set represents the entire deployment period of the temperature logger, followed by seasonal graphs for the site. The blue line indicates water temperature recorded at a 30-minute interval, and the red line indicates the 18°C threshold protective of steelhead and other sensitive species.

The temperature logger at SLU was deployed from the beginning of WY2019 until January 11, 2019, then redeployed for the summer until end of WY2019. Spring data was not collected.

Water Temperature - SLU

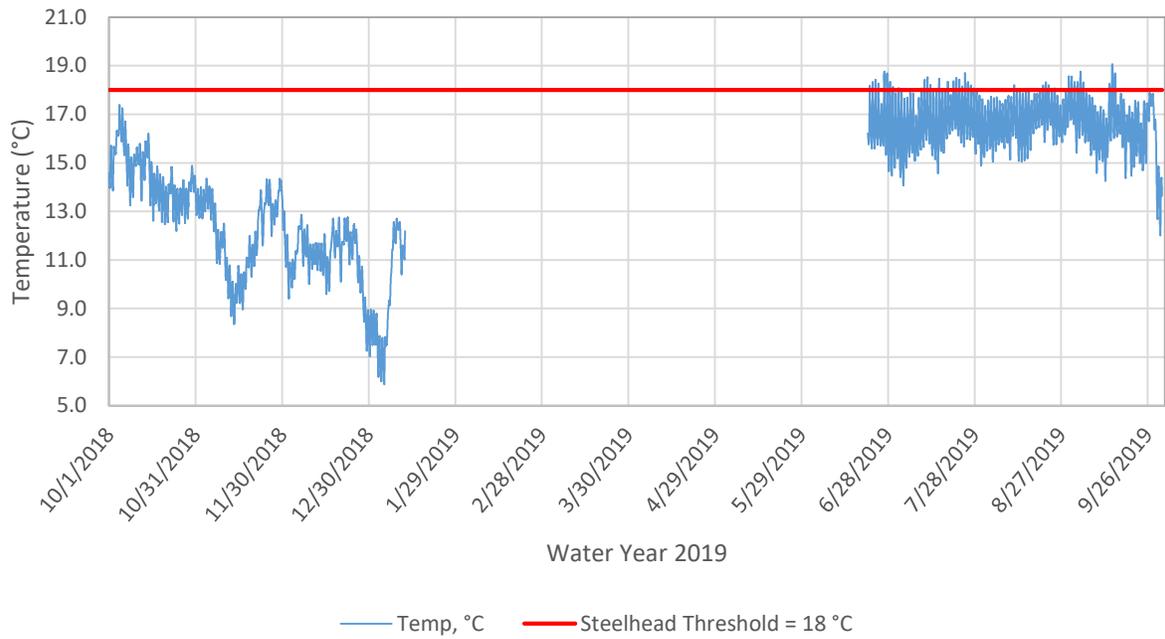


Figure 11

Fall Water Temperature - SLU

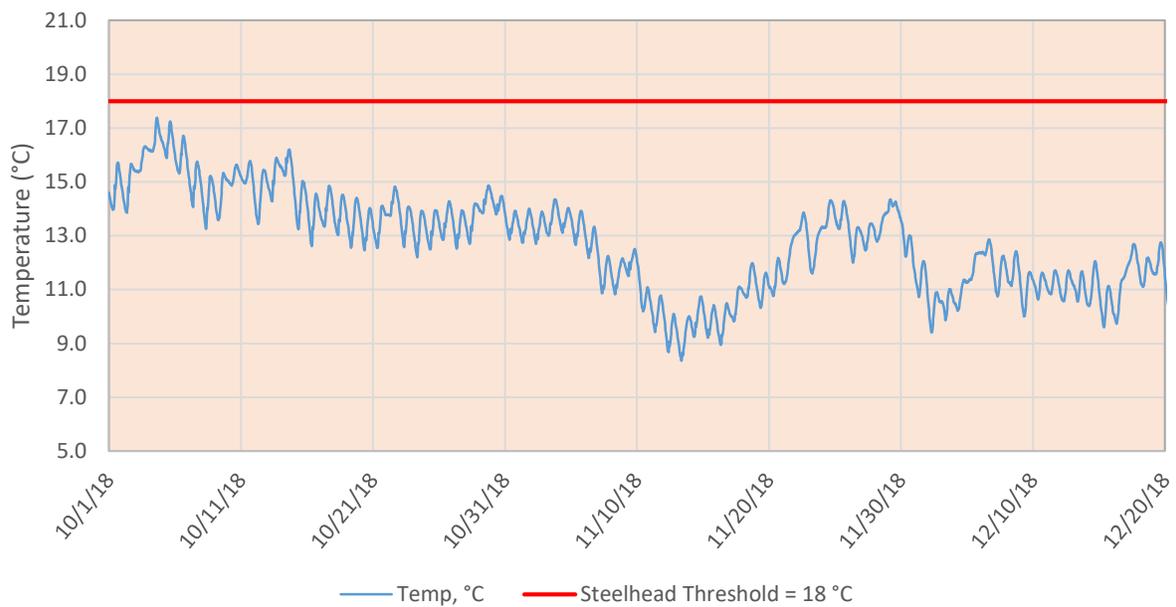


Figure 12

Winter Water Temperature - SLU

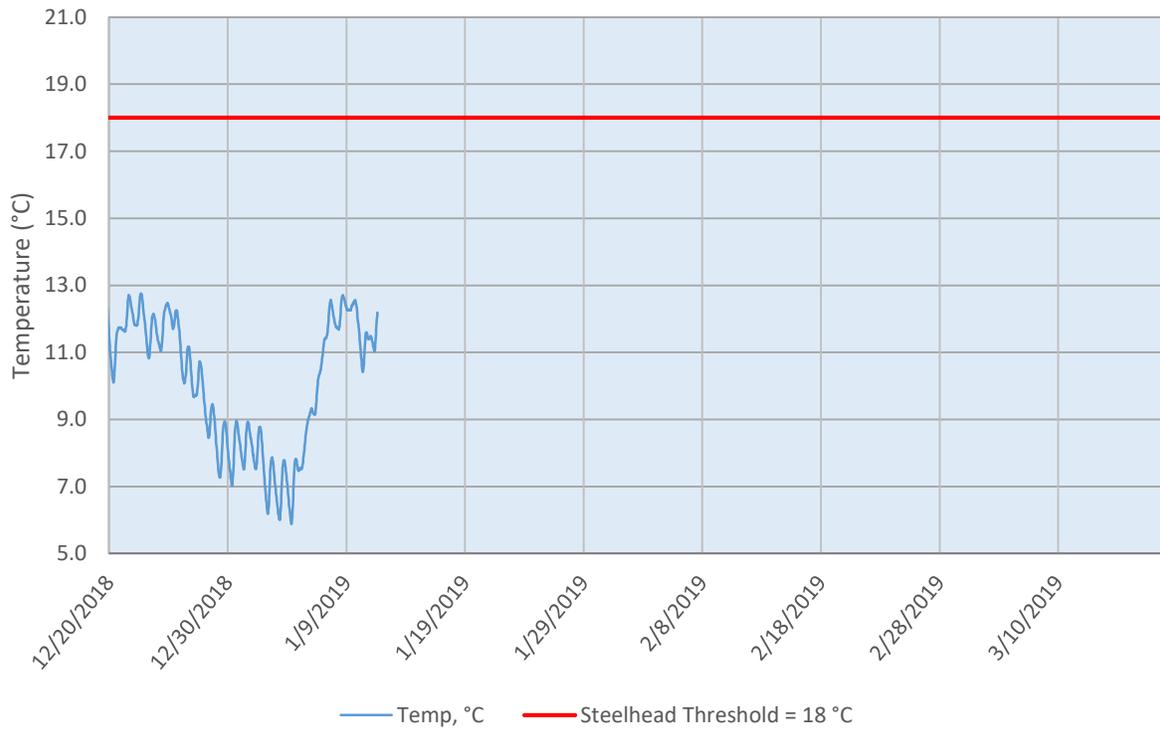


Figure 13

Summer Water Temperature - SLU

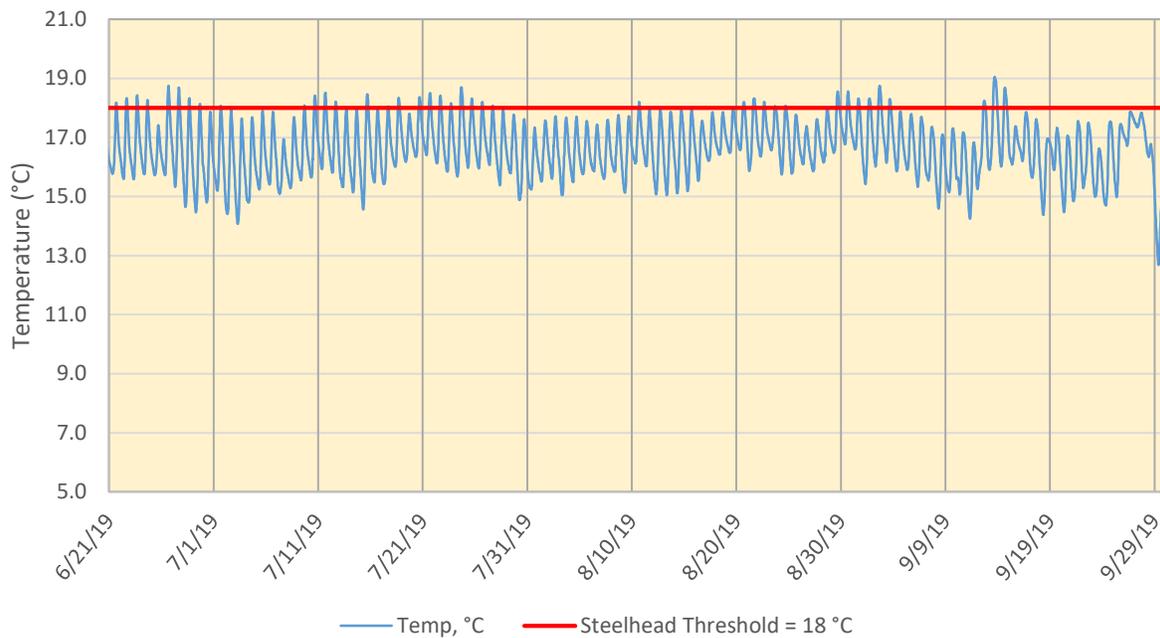


Figure 14

Pennington Creek

Pennington Creek (UPN) is a tributary to Chorro Creek. It's confluence with Chorro Creek is upstream of UCR and downstream of CHO. The temperature logger for Pennington Creek was located about 2.5 miles upstream of the confluence with Chorro Creek, upstream of the Rancho El Chorro Outdoor School and near the Cal Poly Beef Center at the Escuela Ranch.

The first graph represents the entire deployment period of the temperature logger, and following are seasonal graphs for UPN. The blue line indicates water temperature recorded at a 30-minute interval, and the red line indicates the 18°C threshold protective of steelhead and other sensitive species.

The temperature logger at UPN was deployed from November 26, 2018 until the end of WY2019.

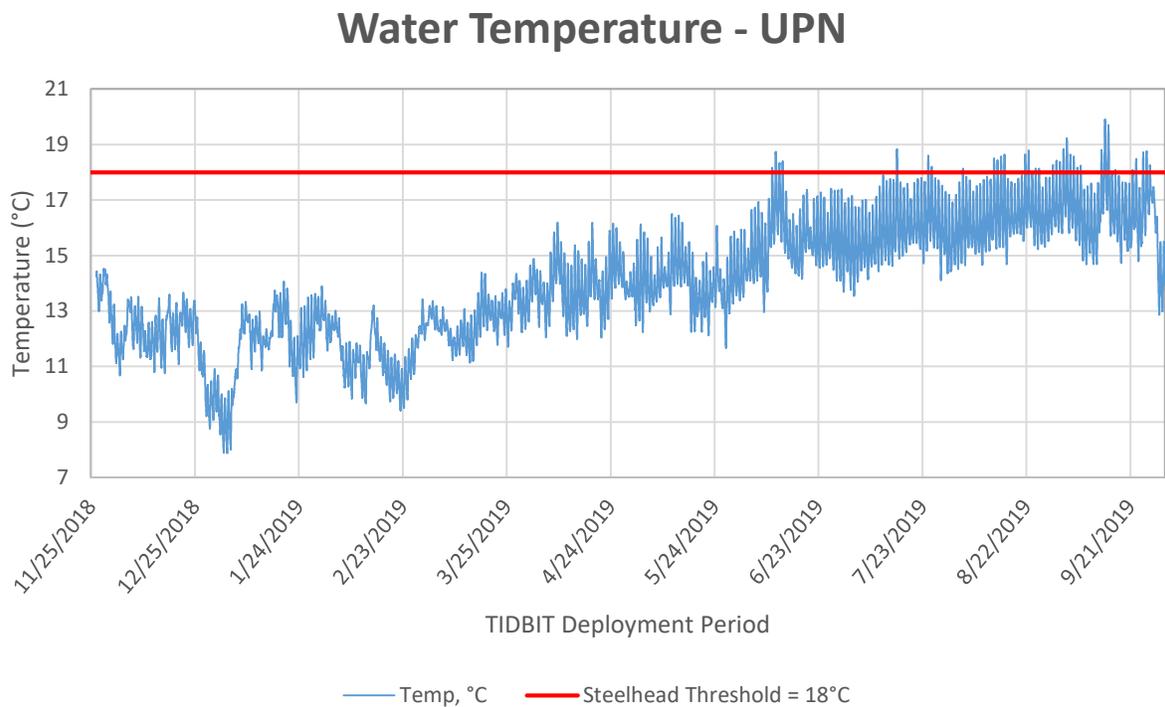


Figure 15

Fall Water Temperature - UPN

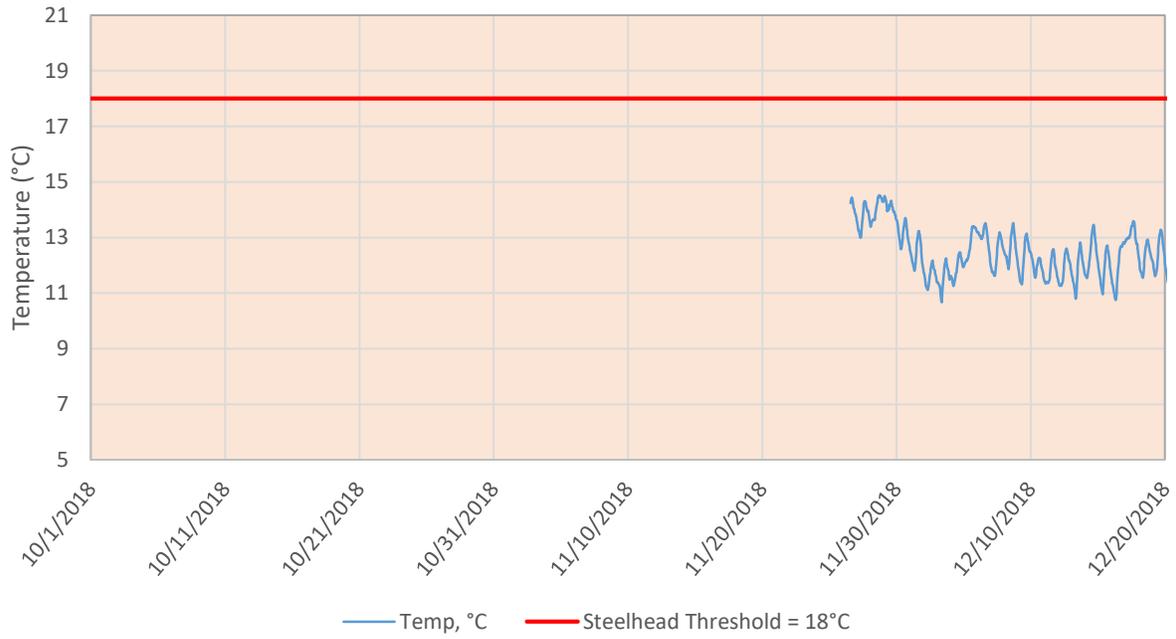


Figure 16

Winter Water Temperature - UPN

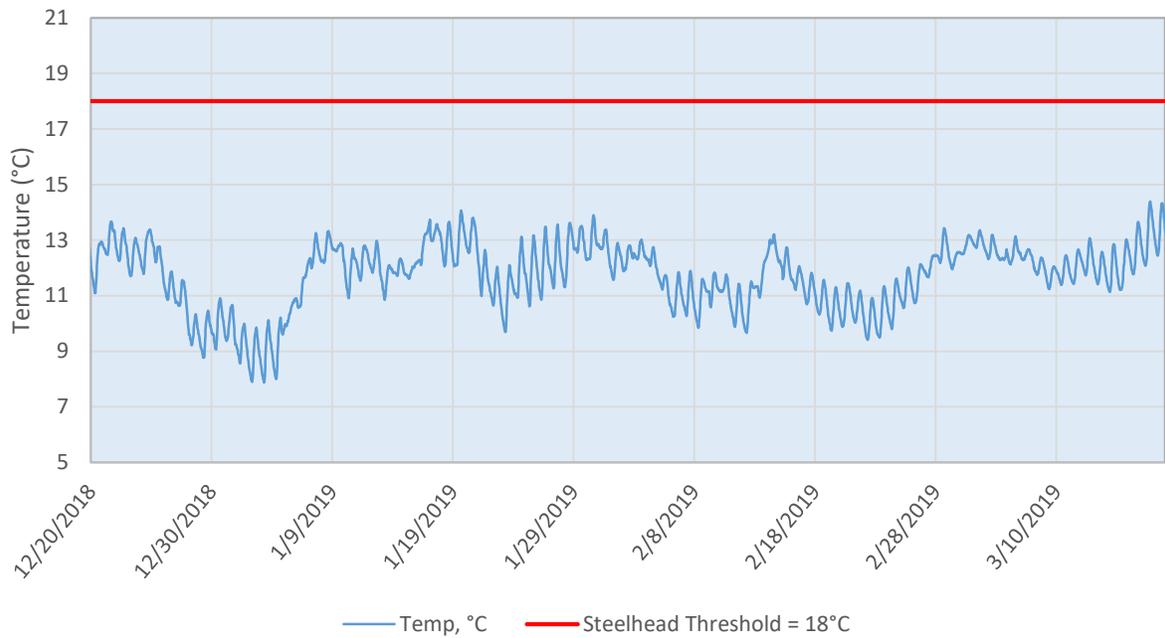


Figure 17

Spring Water Temperature - UPN

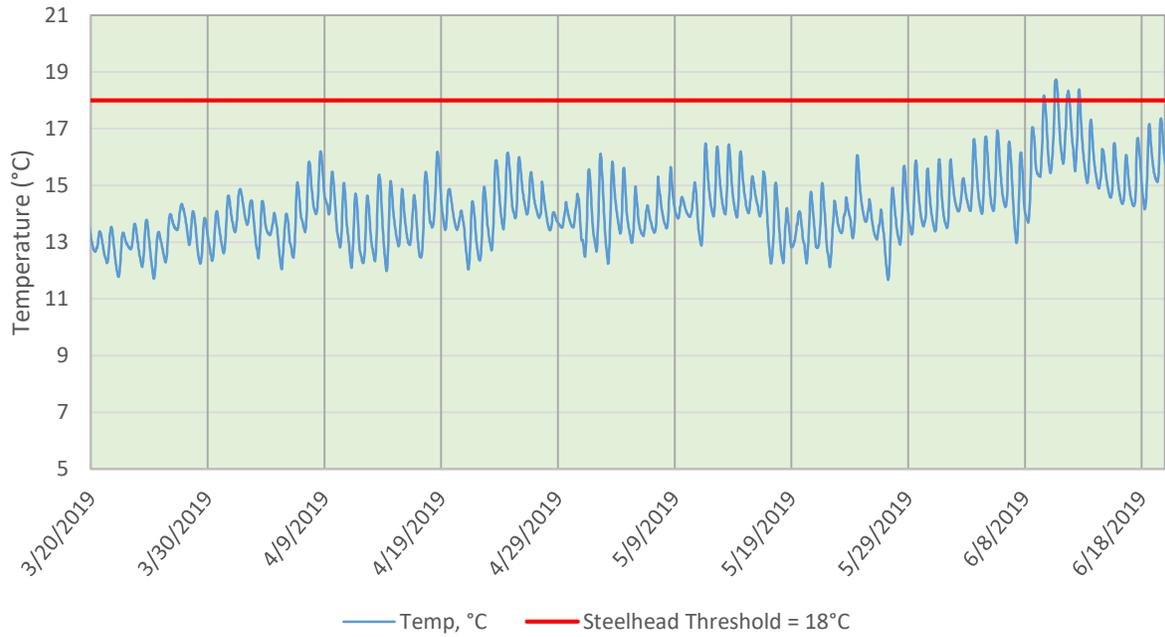


Figure 18

Summer Water Temperature - UPN

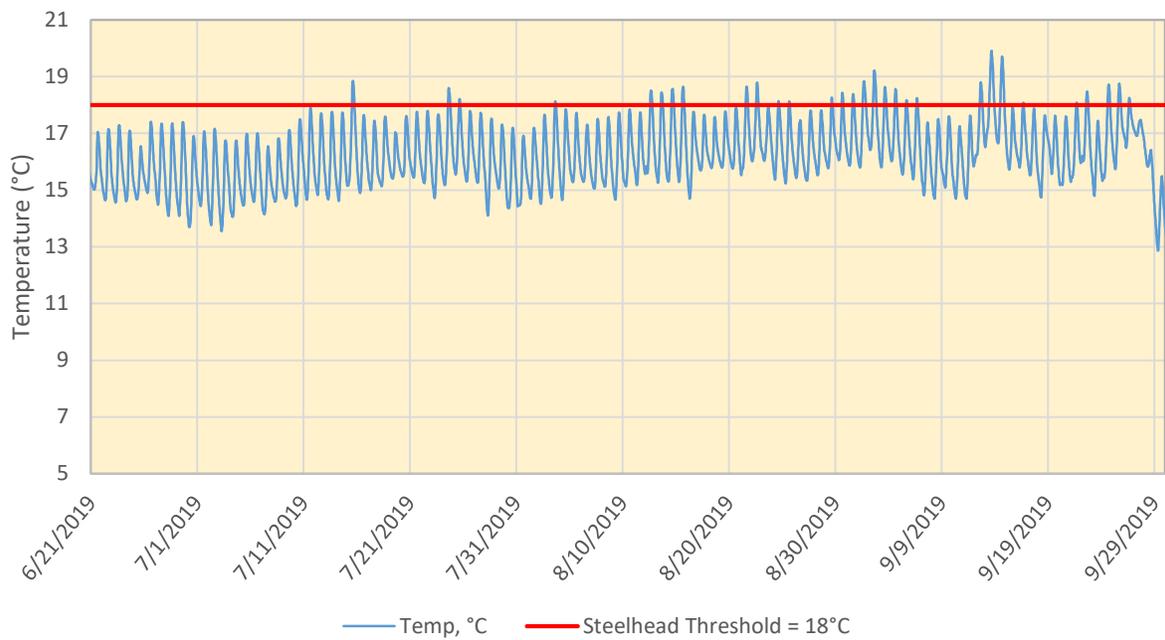


Figure 19

Discussion:

Water temperatures were analyzed using percent exceedance of an 18°C threshold, both over the full deployment period of the TidbiT temperature logger and at a seasonal level (Table 1). Statistics for the deployment period of each logger are shown in Table 2. For more information on logger deployment periods and calculated percent exceedance of the 18°C threshold, refer to Appendix A.

The US Environmental Protection Agency (EPA) sets forth water temperature criteria in the [1986 Quality Criteria for Water](#) (also known as the “Gold Book”), where it recommends the use of a maximum weekly average temperature (MWAT) as an index for assigning protective temperature standards for fisheries. This index is typically used in reference to an upper limit, such as the 18°C threshold. MWAT values for each of the TidbiT monitoring sites can be seen in Table 2. MWAT values are represented spatially in Figure 20.

Maximum Weekly Average Temperatures (MWAT)

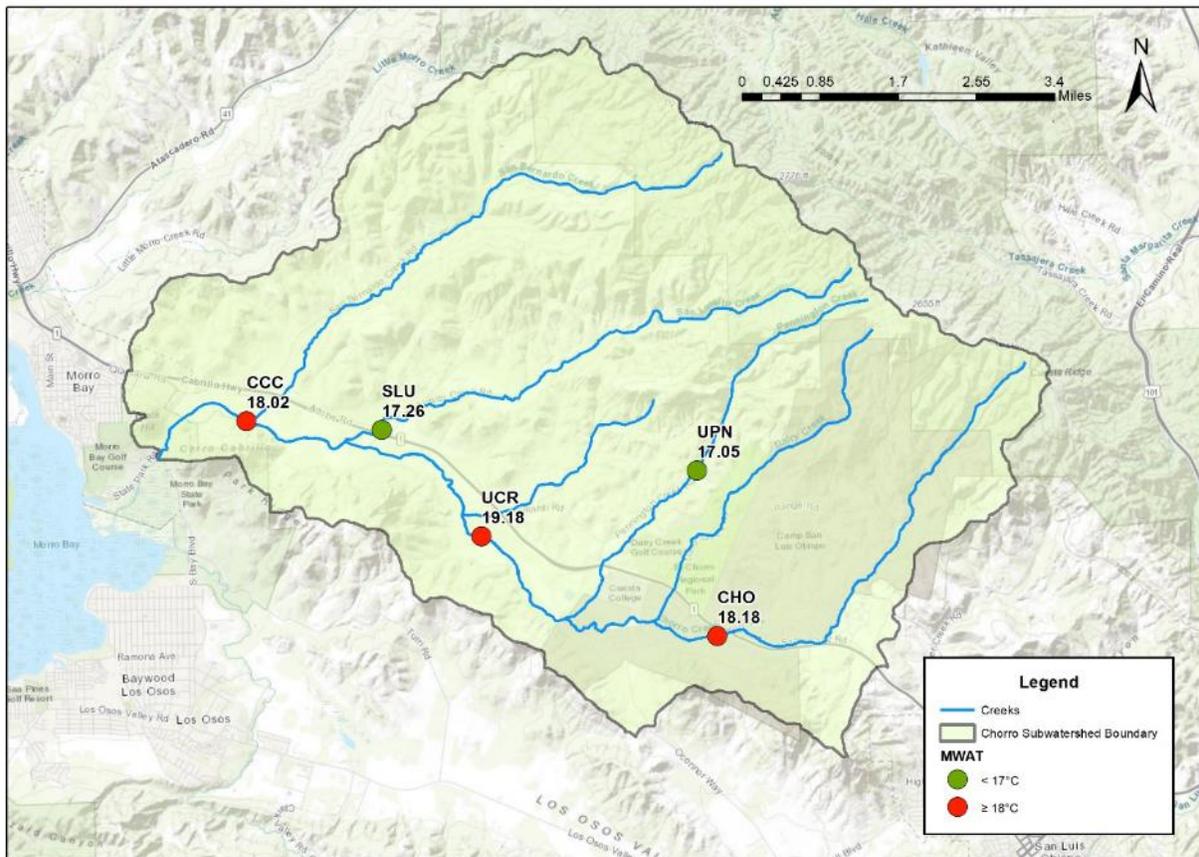


Figure 20: Maximum weekly average temperature (MWAT) for each continuous temperature monitoring site.

Percent of Readings above the 18°C Threshold					
Timeframe	Site				
	CHO	UCR	CCC	UPN	SLU
Full Deployment Period	18.2%	-	-	2.2%	-
Fall Season	0.2%	-	-	0.0%	0.0%
Winter Season	0.0%	-	-	0.0%	0.0%
Spring Season	26.6%	-	12.4%	0.9%	-
Summer Season	40.0%	66.7%	19.3%	5.9%	6.5%

Table 1: Seasonal water temperature percent exceedance for TidbiT monitoring sites. Note that a Full Deployment Period value could not be calculated for all sites as deployments were not year-round at all locations.

	CHO	UCR	CCC	UPN	SLU
Maximum Temperature, °C	20.4	21.5	20.1	19.9	19.1
Maximum Weekly Average Temperature, °C	18.2	19.2	18.0	17.0	17.3

Table 2: Water temperature statistics for TidbiT monitoring sites.

Chorro Creek

All three sites along Chorro Creek exceeded the 18°C threshold throughout their deployment periods. The warmest temperatures for Chorro Creek sites occurred in August, where UCR exceeded the 18°C threshold for 77.2%, CHO exceeded for 45.4%, and CCC exceeded for 32.1% of the readings.

The highest temperature recorded amongst the five sites was recorded at UCR in July 2019 at 21.5°C. The highest MWAT of 18.2°C also occurred at UCR. This site saw the most frequent exceedances of the 18°C threshold, reaching temperatures greater than 18°C for 66.7% of summer season readings.

Although loggers at UCR and CCC were not deployed during the fall or winter of WY2019, it should be noted that temperatures at CHO also exceeded the 18°C threshold during October, reaching a maximum of 18.13°C. This elevated temperature can be seen in more detail in Figure 3.

San Luisito Creek

Although temperatures at San Luisito Creek were significantly cooler compared to those along Chorro Creek, water temperatures still exceeded the 18°C threshold between June and September. Exceedances of the threshold occurred for 6.5% of all summer readings.

Pennington Creek

Pennington Creek had the lowest percentage of exceedances during summer months, only exceeding the 18°C threshold during 5.9% of its readings. It also had the lowest MWAT of the sites at 17.1°C.

On Chorro Creek, it appears that UCR has the most frequent and sustained issues with elevated temperature, given that the percent of summer readings above 18°C is so high. This site is immediately

downstream from a discharge point source, the California Men’s Colony Wastewater Treatment Plant. Their treated discharge goes into the creek and could potentially be contributing to the elevated water temperatures. Elevated temperatures are less frequent downstream, possibly due to cooler water coming in from tributaries (as evidenced by the temperature data from UPN and SLU) and increased canopy cover.

Quarterly Nutrient Monitoring

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

Estuary Program staff visit nine sites to collect samples for laboratory analysis for nitrate as nitrogen (NO₃-N, mg/L) and for orthophosphate as phosphorus (PO₄-P, mg/L). Initially, sites were visited four times a year. As of June 2019, sites are now visited six times a year.

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 (MDL)	0.025 mg/L
Project Quantitation Limit (PQL)	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 (MDL)	0.017 mg/L
Project Quantitation Limit (PQL)	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.

For each nitrate and phosphate result that was less than the PQL, a random number between 0 and the PQL was generated in R and used for analyses in this report. This is the same method utilized by the Central Coast Regional Water Quality Control Board (CCRWQCB) to deal with non-detects in their own analysis.

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 the map below (Figure 21) for site locations.

Morro Bay Watershed Quarterly Nutrient Monitoring Sites

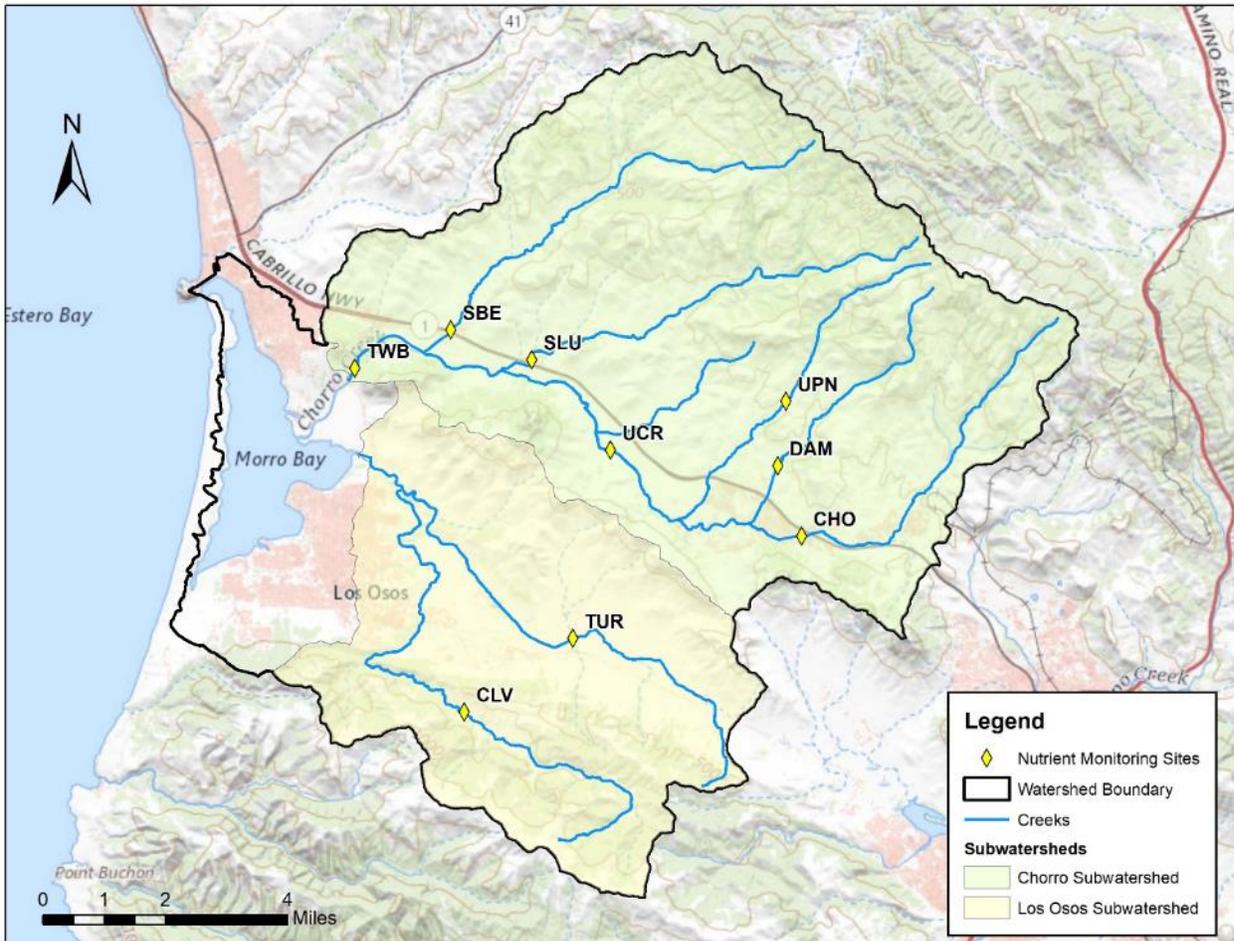


Figure 21

Nitrate as Nitrogen

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 ($\text{NO}_3\text{-N}$) concentrations are greater or equal to 1 mg/L as N and if the site shows other signs of impact such as widespread algal growth and low dissolved oxygen (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 as N. 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 following map (Figure 22) indicates the monitoring locations and the average nitrate as nitrogen concentration at each site for WY2019. 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 2019

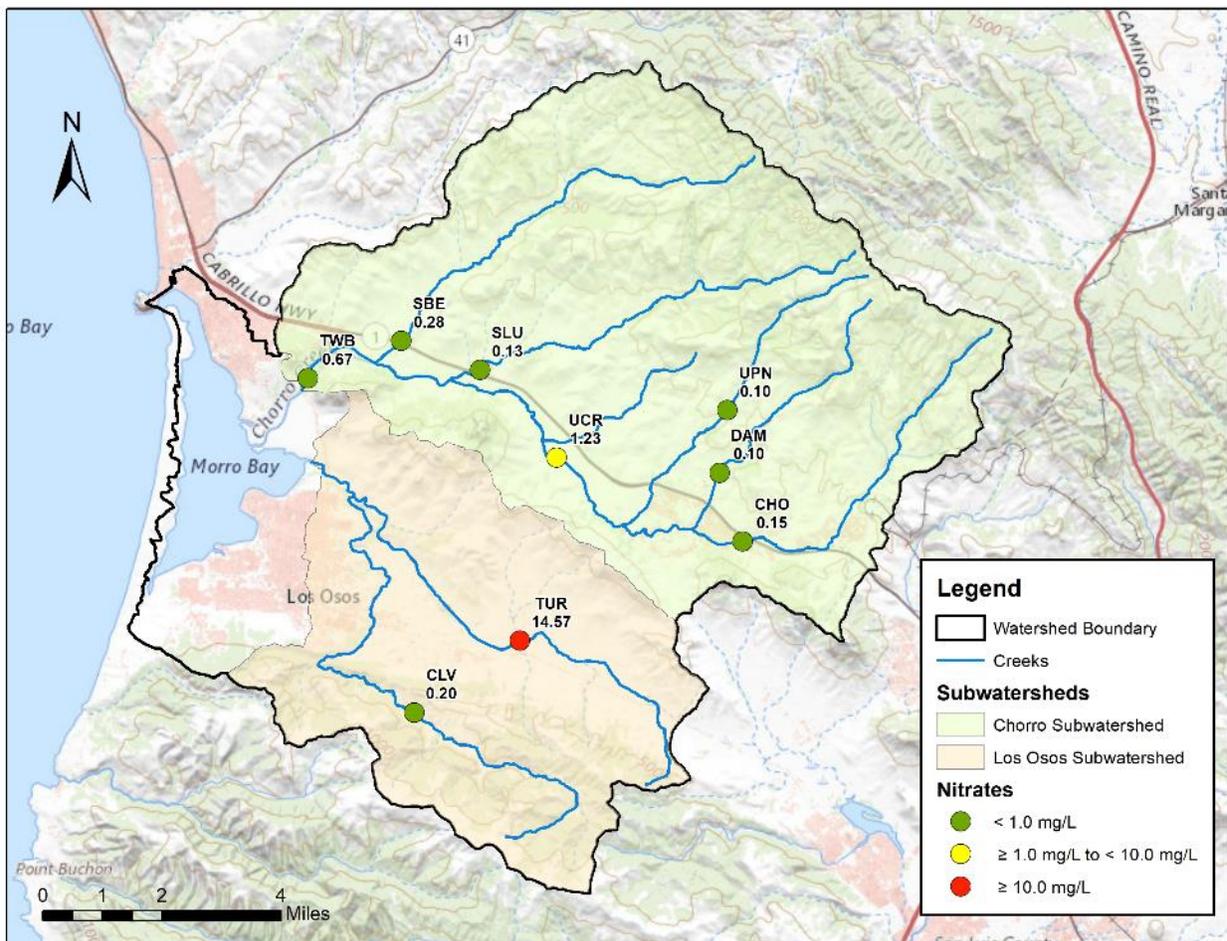


Figure 22

Changes from the historical nitrate average are compared to results from WY2019 and summarized in Table 3 below.

Nitrates as Nitrogen (mg/L)

Site Code	CHO	UCR	TWB	DAM	UPN	SLU	SBE	TUR	CLV
Historical Average, NO₃-N mg/L	0.14	2.44	0.79	0.07	0.08	0.13	0.45	12.59	0.12
WY2019 Average, NO₃-N mg/L	0.14	1.23	0.67	0.05	0.07	0.12	0.28	14.57	0.20
Relative Percent Difference (%)	0.00	65.94	16.44	33.33	13.33	8.00	46.58	14.56	47.10

Table 3: Values highlighted in green had an average nitrate concentrations considered Good (<1mg/L) for WY2019. Values highlighted yellowed had an average nitrate concentration considered Fair (≥ 1 mg/L and < 10 mg/L), and values highlighted red were considered Poor (≥ 10 mg/L). Historical data includes quarterly monitoring from WY2016 through WY2019. The Relative Percent Difference compares the WY2019 data to the historic data.

Orthophosphate 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 (PO₄-P) 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 following map (Figure 23) indicates the monitoring locations and the average orthophosphate as phosphorus concentrations at each site for WY2019. 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 2019

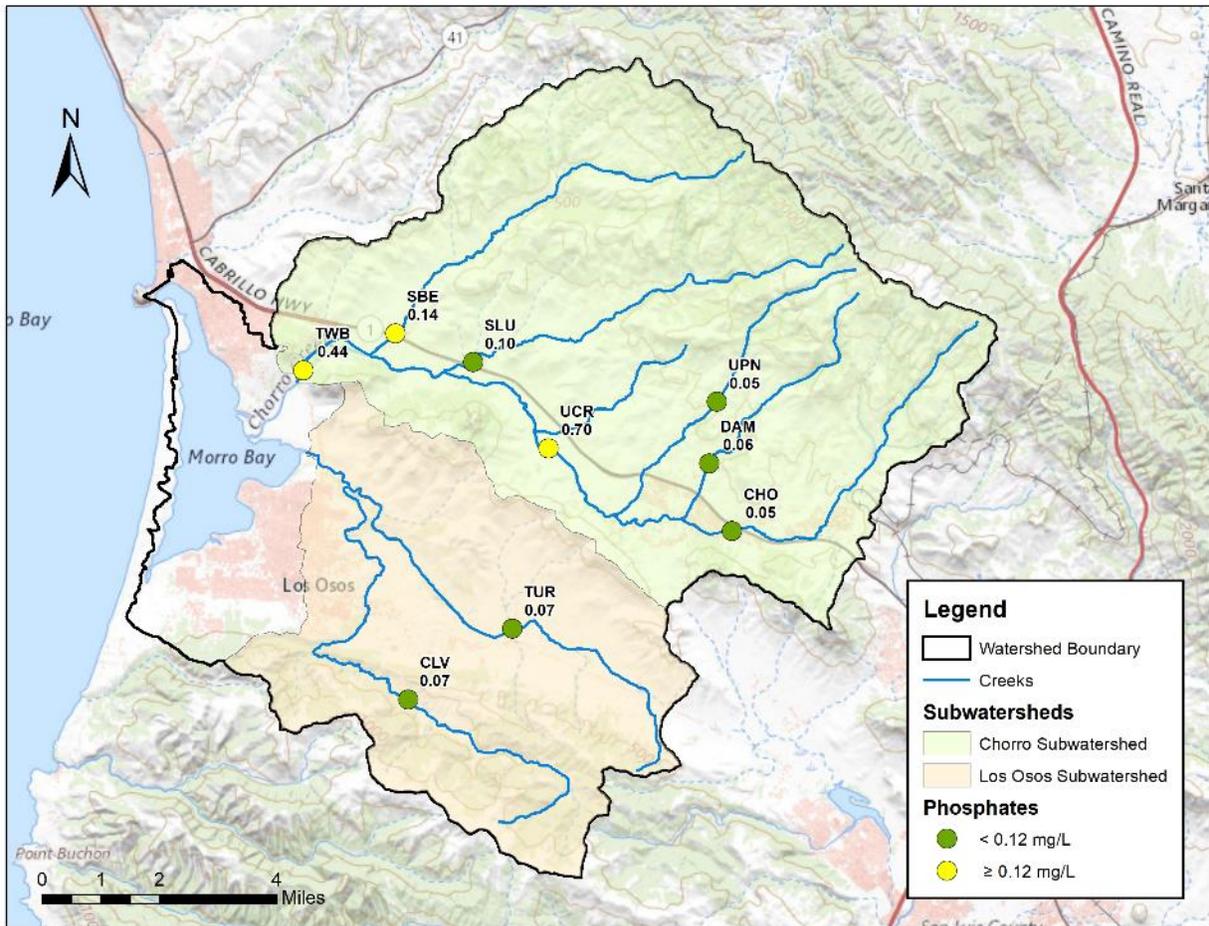


Figure 23

Changes from the historical average phosphate are compared to results from WY2019 are below in Table 4.

Orthophosphate as Phosphorus (mg/L)

Site Code	CHO	UCR	TWB	DAM	UPN	SLU	SBE	TUR	CLV
Historical Average, PO₄-P mg/L	0.03	0.85	0.42	0.06	0.04	0.10	0.14	0.05	0.04
WY2019 Average, PO₄-P mg/L	0.03	0.70	0.44	0.06	0.04	0.10	0.14	0.05	0.03
Relative Percent Difference (%)	0.47	19.35	4.65	6.28	8.18	1.18	2.35	1.53	51.50

Table 4: Values highlighted in green are below 0.12 mg/L. Values highlighted yellow are above 0.12mg/L. Historical data includes quarterly monitoring from WY2016 through WY2019. The Relative Percent Difference compares the WY2019 data to the historic data.

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.

Nutrient impairment often tracks with large DO fluctuations and excess algae. As continuous DO data is not available for WY2019, temperature can be used as a proxy to estimate when DO levels were likely low. For example, UCR experienced elevated temperature in 66.7% of the summer season. Thus, it is likely that less-than-ideal DO conditions occurred during the summer of WY2019 and nutrient enrichment could have played a role.

The presence of algae is also an indicator of nutrient impairment. Although the Estuary Program collects observational data when conducting quarterly nutrient monitoring, data collected to date is too limited to report. The Estuary Program hopes to 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 temperature data, contact the Estuary Program.

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

Appendix A: Temperature Exceedance and Logger Deployment

CHO				
Time Period	# of Times Temp Exceeds 18°C	Total # Temp Readings	Percent Exceedance	Actual Deployment Date
Full Logger Deployment	2305	12670	18.2%	(10/1/2018 - 2/12/2019) - (5/24/2019 - 9/30/2019)
Fall (10/1/2018 - 12/20/2018)	6	3888	0.2%	10/1/2018 - 12/20/2018
Winter (12/21/2018 - 3/19/2019)	0	2564	0.0%	12/21/2018 - 2/12/2019
Spring (3/20/2019 - 6/20/2019)	339	1274	26.6%	5/24/2019 - 6/20/2019
Summer (6/21/2019 - 9/30/2019)	1960	4896	40.0%	6/21/19 - 9/30/2019
UCR				
Time Period	# of Times Temp Exceeds 18°C	Total # Temp Readings	Percent Exceedance	Actual Deployment Date
Full Logger Deployment	3268	4896	66.7%	6/21/2019 - 9/30/2019
Fall (10/1/2018 - 12/20/2018)	-	-	-	-
Winter (12/21/2018 - 3/19/2019)	-	-	-	-
Spring (3/20/2019 - 6/20/2019)	-	-	-	-
Summer (6/21/2019 - 9/30/2019)	3268	4896	66.7%	6/21/2019 - 9/30/2019
CCC				
Time Period	# of Times Temp Exceeds 18°C	Total # Temp Readings	Percent Exceedance	Actual Deployment Date
Full Logger Deployment	1157	6645	17.4%	5/15/2019 - 9/30/2019
Fall (10/1/2018 - 12/20/2018)	-	-	-	-
Winter (12/21/2018 - 3/19/2019)	-	-	-	-
Spring (3/20/2019 - 6/20/2019)	211	1701	12.4%	5/15/2019 - 6/20/2019
Summer (6/21/2019 - 9/30/2019)	946	4896	19.3%	6/21/19 - 9/30/2019
SLU				
Time Period	# of Times Temp Exceeds 18°C	Total # Temp Readings	Percent Exceedance	Actual Deployment Date
Full Logger Deployment	317	9823	3.2%	(10/1/2018 - 1/11/2019) - (6/12/2019 - 09/30/2019)
Fall (10/1/2018 - 12/20/2018)	0	3888	0.0%	10/1/2018 - 12/20/2018
Winter (12/21/2018 - 3/19/2019)	0	1039	0.0%	12/21/2018 - 1/11/2019
Spring (3/20/2019 - 6/20/2019)	-	-	-	-
Summer (6/21/2019 - 9/30/2019)	317	4896	6.5%	6/21/19 - 9/30/2019
UPN				
Time Period	# of Times Temp Exceeds 18°C	Total # Temp Readings	Percent Exceedance	Actual Deployment Date
Full Logger Deployment	327	14802	2.2%	11/26/2018 - 9/30/2019
Fall (10/1/2018 - 12/20/2018)	0	1172	0.0%	11/26/2018 - 12/20/2018
Winter (12/21/2018 - 3/19/2019)	0	4270	0.0%	12/21/2018 - 3/19/2019
Spring (3/20/2019 - 6/20/2019)	39	4416	0.9%	3/20/2019 - 6/20/2019
Summer (6/21/2019 - 9/30/2019)	288	4896	5.9%	6/21/19 - 9/30/2019

= logger only deployed for partial time period
- = logger not deployed for entire time period

Table A1 – Tidbit deployment timeframes